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Respiratory Metabolism of Sugar Beets[1]

MYRON STOUT AND JOHN D. SPIKES[2]

Introduction

The sugar beet has an unusually favorable balance between photosynthesis and respiration. It far outranks all other temperate zone plants in its ability to photosynthesize and accumulate food on a per acre basis (3)[3]. In agricultural practice, huge quantities of sugar beets must be stored for extended periods. During storage the beets respire and, as a result large quantities of sugar are lost. If ways could be developed for decreasing this loss, it would be of obvious practical value. At present, the most practicable method of decreasing respiratory sugar losses is the forced-ventilation technique (1). The respiratory rate of the stored beets is decreased by forcing cool air through the beet piles. This reduces the temperature and thus decreases the respiratory rate and consequent sugar loss.

Another obvious approach to the control of beet respiration is the use of chemical inhibitors. For this purpose it is desirable to know something of the various enzymatic reactions which make up the over-all respiratory process in sugar beets. Although considerable research on respiration has been carried out with animal tissues and with certain plant tissues (2), little is known of the intermediary reactions in sugar beet respiration. The present report deals with some preliminary studies on the effects of a number of chemicals which are known to inhibit certain enzymes. It is hoped that basic studies of this type will provide a foundation for more detailed studies of the application of chemical inhibitors for the reduction of sugar beet respiration. In addition, such information will be useful in studies being carried out on the effects of ionizing radiations on sugar beet metabolism and storage.

Materials and Methods

Respiratory measurements were carried out with the standard manometric (Warburg) technique (7), using tissues from large (2.5 lb.) sugar beets of the variety SL 202. The beets were harvested in November and were stored in darkness in a root cellar at a temperature of 40° F. Most of the experiments were performed during the following March and April.

Conical vessels (16 ml.) with side arms and without center wells were used. Each vessel contained 25 slices of beet tissue (1.0 mm. thick x 8.5 mm. diameter, wet weight approximately 1.5 grams, dry weight approximately 0.25 grams) in a total of 4.0 ml. of solution. The final reaction solution was 0.4 *M* in sucrose, 0.05 *M* in potassium phosphate buffer of pH 6.8, and 0.04 *M* in potassium chloride unless otherwise specified. For pH values below 5.7, 0.05 *M* citrate buffer was used. Inhibitors were added to give the

[1] Cooperative investigations between the Field Crops Research Branch, ARS, USDA and the University of Utah. Investigations conducted at the University of Utah were supported in part by grants from the Atomic Energy Commission and the University of Utah Research Fund.

[2] Physiologist, Field Crops Research Branch, ARS, USDA, and Professor of Experimental Biology, University of Utah, respectively.

[3] Numbers in parentheses refer to literature cited.

final concentrations indicated. Carbon dioxide was absorbed by 0.2 ml. of 5 percent potassium hydroxide on a fluted filter paper in the side arm of the vessel.

A shaking rate of 110 oscillations per minute with an amplitude of 2.5 cm. was used routinely after preliminary tests. All respiratory measurements were made at 20° C. after preliminary tests indicated some reduction in the slope of the rate-temperature curve above 25° C. (see Figure 1).

Slices of sugar beet tissue 1.0 mm. in thickness were cut with a hand microtome at right angles to the vertical axis of the beet. Discs of tissue 8.5 mm. in diameter were cut from stacks of 10-15 slices by means of a sharp, stainless steel cork-borer. A simply constructed, adjustable holder kept the tissues in place while cutting the discs. Tissues from near the skin and core of the beet were not used. The discs were washed, with good agitation, for 15 minutes in running cold (13-16° C.) tap water, rinsed three times in distilled water, twice with 0.4 *M* sucrose containing 0.04 *M* KCl, and stored in sucrose-KCl at 1° to 2° C. until used. No discs were used that had been sliced for more than six days, except to study the respiratory rate in relation to time after cutting. There was a small progressive increase in respiratory rate of the cut discs during storage at 1-2° C. Bacterial contamination was usually obvious in discs stored for more than two weeks. Other studies showed that the respiratory rate of discs increased steadily with time during storage with aeration in either water or sucrose-KCl solution. Discs stored in running tap water behaved in the same way. The best technique found was to store the discs without aeration in sucrose-KCl solution at 1-2° C. The medium was changed and the discs were washed in distilled water immediately before use. There was little change in the respiration rate of discs handled in this manner over a period of one week. After the respiration measurements, the discs were washed in distilled water, blotted, and dried at 65-70° C. for about 15 hours. The discs were then weighed and the respiration rates in microliters (mm^3) oxygen per gram dry weight per hour calculated to 0° C., and 760 mm. pressure.

Experimental Results

Temperature had a large effect on the respiratory rate of sugar beet discs as shown in Figure 1. The rate vs. temperature curve is sigmoid in shape and shows a very definite reduction in slope above 25° C. Preliminary studies showed that discs 1-1.5 mm. in thickness exhibited a maximum rate of respiration as shown in Figure 2. Discs of this optimum thickness suspended in 4 ml. of solution respired at essentially the same rate as similar discs impaled on stainless steel wire so they did not touch each other, and measured in water-saturated air. This latter experiment indicated that oxygen availability was probably not limiting in the media in which the Warburg measurements were made.

Sugar beet roots are made up of alternate rings of vascular and parenchymatous tissues. Slices 1 mm thick were separated roughly into the two kinds of tissues and respiratory rates were determined for each tissue. The data in Table 1 show that on a fresh weight basis the vascular tissue had the higher respiratory rate. When compared on a dry weight basis, however, the

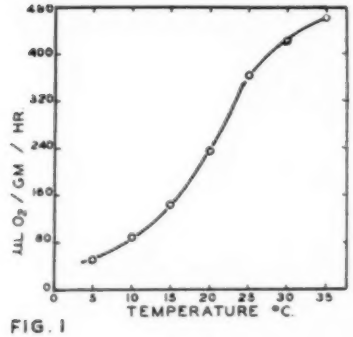

FIG. 1

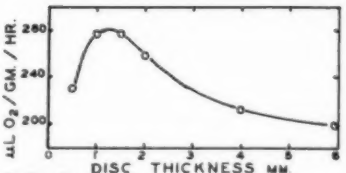

FIG. 2

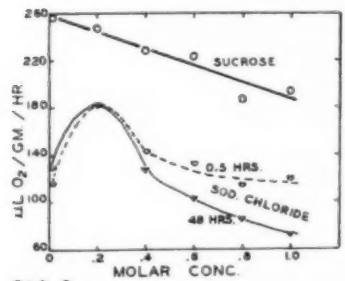

FIG. 3

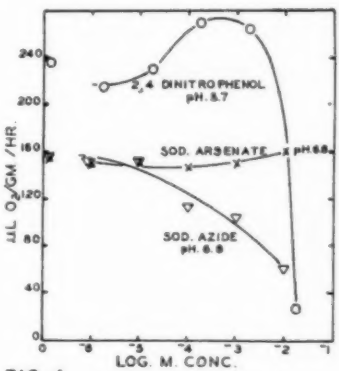

FIG. 4

Figures 1 to 4.—The effect of: 1, temperature; 2, disc thickness; 3, sucrose and sodium chloride concentration; and 4, reagents affecting phosphate transfers on the respiration rate of sugar beet root tissues.

parenchyma respired more rapidly due to the much greater percentage of dry matter in the vascular tissue. An increase in the sucrose concentration of the medium in which the tests were made caused a reduction in respiratory rate as shown in Figure 3. Previous studies with whole beets (5) and with 10-gram pieces of tissue (4) have shown that there is, in general, a positive correlation between the sucrose concentration in the tissue and respiratory rate.

Table 1.—Respiratory Rate of Vascular vs. Parenchyma Tissue at 25° C.

Tissue	ul 0_2/gm./hr.		Dry matter
	Fresh wt.	Dry wt.	Percent
Vascular	55.5	333.	16.7
Parenchyma	43.7	404.	10.8

Sugar beet tissues in the present studies showed a pronounced increase in respiratory rate as the sodium chloride concentration of the media was increased. The maximum "salt respiration" occurred at about 0.2 *M* NaCl as shown in Figure 3. Higher concentrations resulted in a decreased respiratory rate.

Inhibitor Studies

For convenience in presenting the results, inhibitors have been grouped according to the apparent mechanism by which they affect enzymes or enzyme systems. The system of grouping the inhibitors is the same as that used in the review paper of James (2) which may be examined for a more detailed discussion of the mechanisms by which inhibitors interfere with plant respiration.

Reagents Affecting Phosphate Transfer—Inhibitors in this category affect metabolic processes of many types by preventing the synthesis of energy-rich phosphorus compounds. Respiration may continue and even may be stimulated. Compounds of this type examined with respect to their effects on sugar beet respiration included 2,4-dinitrophenol, sodium arsenate, and sodium azide. The figures show that 2,4-dinitrophenol stimulated respiration at low concentrations (10^{-4} to 10^{-3} *M*) and strongly inhibited respiration at higher concentrations. These effects were only slightly influenced by pH. Sodium arsenate had little effect. Sodium azide inhibited sugar beet respiration, probably by interfering with metallic oxidase activity (as will be discussed later) rather than by any effect on phosphate transfer.

Thiol Reagents—Many enzymes involved in respiration are active only when surface sulfhydryl (-SH) groups are free. Inhibitors can act by combining with -SH groups thereby inactivating the enzyme involved. Figure 5 shows the effects of two inhibitors in this group, iodoacetamide and sodium arsenite, on sugar beet respiration. In these short-term experiments iodoacetamide inhibited only moderately. Sodium arsenite was more effective, giving 50 percent inhibition at 10^{-3} *M*. Since compounds of this type react slowly, longer periods of contact might result in greater inhibition.

Carbonyl Reagents—Some of the steps in the respiratory process can be inhibited by compounds such as hydroxylamine and sodium cyanide which react with essential carbonyl groups. As shown in Figure 6, both hydroxylamine and cyanide inhibit the respiration of sugar beet tissue. Since cyanide can also inhibit by other mechanisms as discussed below, it is difficult to speculate on the details of the mechanisms involved here.

Reagents Forming Fluorophosphate—Fluoride inhibits the enzyme enolase which catalyzes an essential step in the respiratory process, the conversion of phosphoglyceric acid to phosphopyruvic acid. Figure 7 shows that sugar beet respiration is inhibited by sodium fluoride. Inhibition was increased with decreasing pH, because of an increased permeability of the cells to the inhibitor.

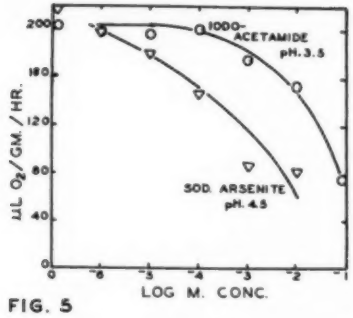

FIG. 5

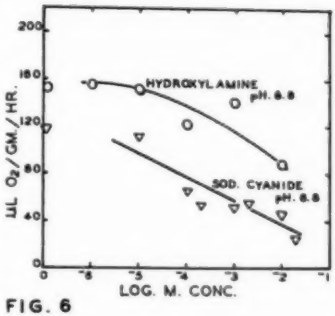

FIG. 6

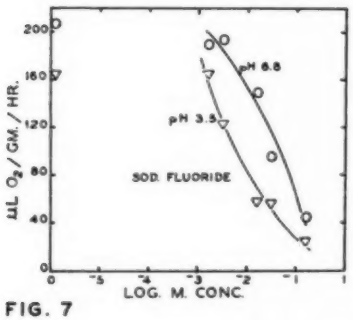

FIG. 7

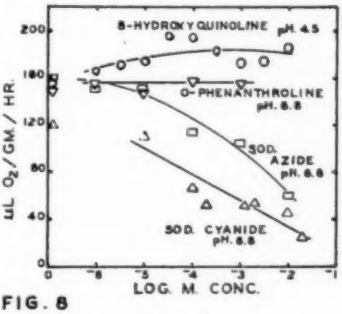

FIG. 8

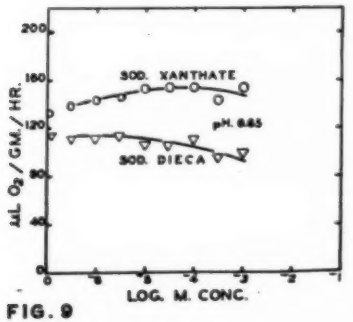

FIG. 9

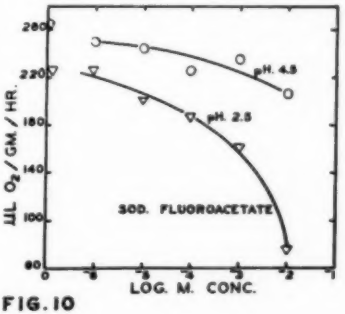

FIG. 10

Figures 5 to 10. The effect of chemical inhibitors on the respiration rate of sugar beet root tissues: 5, thiol reagents; 6, carbonyl reagents; 7, reagents forming fluorophosphates; 8 and 9, reagents forming complexes with transition metals; and 10, reagents for oxaloacetic acid.

Reagents Forming Complexes with Transition Metals—A number of the enzymes involved in respiration contain iron or copper. Inhibitors such as cyanide and azide interfere with the activity of these enzymes, especially cytochrome oxidase, by combining with the metallic component. Figure 8 shows that both sodium cyanide and sodium azide inhibit the respiration of sugar beet tissue. Azide is less effective which would be expected since it does not usually form as stable complexes as cyanide.

A number of enzymes are inhibited by 8-hydroxyquinoline. Ascorbic acid oxidase is especially sensitive to this compound. Since sugar beet tissue is inhibited by cyanide and azide, but not by 8-hydroxyquinoline, as shown in Figure 8, it may be presumed that the respiration is mediated by way of a cytochrome oxidase or polyphenoloxidase rather than by ascorbic acid oxidase. As shown in the same figure, sugar beet respiration is insensitive to o-phenanthroline which strongly chelates ferrous iron.

Sodium diethyldithiocarbamate (DIECA) chelates copper and as a result strongly inhibits ascorbic acid oxidase. It also chelates iron under some conditions but has little effect on cytochrome oxidase at low concentrations. Sodium xanthate also chelates copper but not as strongly as DIECA. As shown in Figure 9, neither of these compounds at low concentrations inhibits the respiratory rate of sugar beet tissue. These results agree with the data obtained with 8-hydroxyquinoline.

Reagent for Oxaloacetic Acid—Sodium fluoroacetate can inhibit respiration by combining with oxaloacetic acid and thereby blocking the citric acid cycle. Figure 10 shows that sodium fluoroacetate inhibits sugar beet respiration at low pH, probably because it penetrates into the cells more rapidly under such conditions.

Miscellaneous Inhibitors—Some phenols inhibit respiration, apparently by forming complexes with copper-containing proteins. Resorcinol was found to reduce the respiration of sugar beet tissue. Since a concentration of 8×10^{-2} *M* was required for a 50 percent decrease, the effect is probably not very specific.

Malonic acid competitively interferes with the oxidation of succinic acid by the enzyme succinic dehydrogenase in the citric acid cycle. Since the inhibition is competitive, addition of more succinic acid will reverse the effect. In the present work the picture of malonic acid inhibition and reversal was not too clear, probably due to slow rates of penetration of the compounds into the sugar beet tissue. It appears, though, that malonic acid does inhibit to some extent and that this inhibition can be reversed by succinate.

Maleic hydrazide had little or no effect on the respiration of sugar beet root tissue at pH 6.8 or 3.5. Previous studies (6) have also shown that it had little or no effect on the respiration of whole roots when applied as a pre-harvest foliar spray or when the roots were dipped in a solution of maleic hydrazide after harvest.

Summary

Preliminary studies have been made on the respiratory metabolism of sugar beet root tissues using the Warburg technique and respiratory inhibitors. Techniques of preparing, handling, and storing tissue discs were developed. On the basis of the effects of various types of inhibitors, it would appear that sugar beet root respiration involves cytochrome oxidase or polyphenol oxidase rather than ascorbic acid oxidase.

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New Filter Fabrics

IRA A. RESCH[1]

With the price of cotton fabrics nearly tripling during World War II and the advent of the fabulous synthetic fabrics, the beet sugar industry started a search for better filter fabrics, their goal being to reduce costs and reduce down time on equipment for dressing.

In 1947 the Spreckels Sugar Company tried nylon on our toughest service, the hot saccharate filters. Cotton twill blankets lasted only 48 to 72 hours and, since nylon cost 3 to 4 times as much as twill, we had to get over 10 days' service from a nylon blanket to break even—not considering labor and wire costs. No spectacular results were obtained from the first trial but the results indicated that we were on the right track and we gained experience. It was found that cleaning with dilute mineral acid degraded the nylon and it was necessary to keep the blankets wet during interruptions on operations. Later, nylon was tested on the cold saccharate filters and about 90 days' service was obtained compared with an average of 20 days for 15 ounce cotton twill.

In about 1950, the Vinyon N material became available and, because of its chemical resistance characteristics, was not affected by our cleaning acid, and was used extensively on both hot and cold saccharate filters.

Vinyon J-302 was also tested on cold saccharate filters. This particular fabric is suitable for low temperatures only, and phenomenal service life was obtained—279 and 420 days on two blankets. The manufacture of this material in the United States was discontinued, but an equivalent material is available, manufactured under a French patent and is known as Vincel V-1902.

In 1952 the Dynels and Orlons came out. These have proven successful in Steffen filtration, as shown in Tables 1, 2, and 3.

Table 1.—Three-Year Service Record—Cold Saccharate.

No. Used	Style	Avg. Length	Max. Length
7	Dynel No. 2005	175 Days	237 Days
1	Orlon FA-1134	175 Days	175 Days
2	Vinyon N-734	155 Days	181 Days
2	Vinyon J-302)		
3	Vincel V-1902)	277 Days	420 Days
3	15 oz. Cotton Twill	20 Days	

Table 2.—Three-Year Service Record—Hot Saccharate.

No. Used	Style	Avg. Length	Max. Length
6	Vinyon N-734	71 Days	82 Days
12	Dynel No. 2005	97 Days	117 Days
	15 oz. Cotton Twill	2½ Days	

[1] Plant Superintendent Spreckels Sugar Company, Woodland, California.

Table 3.—Three-Year Comparison of Filter Cloth Usage.

Years	Style	Sq. Ft./1000 tons of Molasses	
		Cold	Hot
1943 - 44 - 45	Cotton Twill	719	687
1953 - 54 - 55	Synthetic	47	16

To compare the savings affected by use of synthetic fabrics, we will assume a 100-day campaign of Steffen operation at a 150 ton per day rate, totaling 15,000 tons of molasses worked. (Table 4.)

Table 4.—Savings by Using Synthetic Fabrics.

	15 Oz. Cotton Twill	Dynel No. 2005
Cold Filters out of service	300 Unit Hrs.	12 Unit Hrs
Hot Filters out of service	360 Unit Hrs.	6 Unit Hrs.
Cost of Blankets	$3360	$330
Cost of Wire	$ 820	$ 52
Additional Labor	$ 264	$ 32
TOTAL	$4444	$414

Besides the attractive reduction in costs the equipment is available for nearly 100 percent of the campaign.

So far this paper has covered our toughest problem and consideration will be given to the experience with carbonation vacuum filter fabrics.

For preliminary tests of fabrics the 1/10 square foot Oliver disc is often used, but it will only give an indication of filter rates and clarity and not the life expectancy of a cloth. A 1′ x 1′ drum vacuum filter is also used that can be operated under plant conditions, but if a number of different fabrics are to be compared under identical conditions, a single test unit is not sufficient.

In 1953 Dynel, Orlon, and Vinyon blankets were tested on a full scale filter. These cloths were of the same weave as that used successfully on Steffen filtration, but they blinded after a week or two of operation and the capacity dropped off. The synthetic blankets were tested one at a time so that two of our three filters (dressed with standard cotton) were always available for comparison of results and ready to carry the load. In order to give the synthetics the benefit of the doubt, rather severe cleaning measures were employed, using stronger acid, detergents, and even steam cleaners. After it was finally determined that the weave was improper for carbonation sludge, the blankets were removed and laundered. The Orlon was used for another 131 days on cold saccharate. The Dynel and Vinyon cloths had shrunk and were cut up for hot saccharate filters.

In 1954 materials were obtained to be tested on a 1′ x 1′ vacuum filter, the materials being five different weight and weave Dynels, one Vinyon, one Orlon, and one Dacron. In order to test the materials under identical conditions, it was decided to forego the test on the small filter

and to sew the foot-wide pieces together and insert them into a longitudinal belt in a 15 ounce cotton twill blanket. To evaluate the pickup through the various fabrics, the cake thickness was measured at specified intervals during the life of the cotton blanket. During the 19 days of the test, frequent visual inspections were made to observe the cake discharge and how the cake pickup carried through between scrubbings.

Table 5.—Cake Thickness in 1/16 Inches.

Style	Thickness
Dynel D-2000	8.45
Dynel D-2002	8.17
Dynel D-2003	9.82
Dynel D-2005	8.57
Dacron DA-2103	9.12
Orlon FA-1105	8.8
Vinyon N-734	8.05
18.4 Ounce Dynel Plain Weave	7.27
Control	8.67

All of the test materials were suitable for additional service when the control twill blanket failed.

The D-2003, DA-2103, and the FA-2103 had better pickup ability than the cotton twill.

Microscopic examination of the fabrics after the test run indicated that in all cases the material was only slightly degraded from its original condition.

From observations the Dynel No. 2003 was selected for further testing on plant scale operations, getting 78 and 119 days' service out of the two blankets tried, with satisfactory filtration rate and filtrate clariy.

Intermingled with the probing for a suitable synthetic fabric and weave, it was learned from an intermountain sugar company that they had successfully relieved a carbonation filtration bottleneck by changing to a basket weave cotton cloth known as Style No. 15. This is an inexpensive, lightweight cloth but tests have proven it has high capacity and the clarity of the filtrate is acceptable. In the last two years, a number of these blankets have been used giving an average service of 31 days with a maximum of 56 days. Apparently the secret for the longer service of this light cotton cloth as compared with standard cotton twill is the fact that it usually does not require acid scrubbing for the first week or more, and after that, the frequency and extent of scrubbing required is less than the heavier twills and synthetics.

Except for some partial tests with nylon on a few Second Carbonation Kelly leaves and Standard Liquor P. & F. frames, the foregoing about covers Spreckels Sugar Company's experience with filter fabrics. In both of these two tests it is indicated that additional trials are justified and more tests ar planned on pressure filters completely dressed with synthetics.

One point of interest on cutting synthetics is the use of a carbon arc to ravel-proof the edges without hemming.

Effects of Virus Yellows on Sugar Beet with a Consideration of some of the Factors Involved in Changes Produced by the Disease

C. W. Bennett, Charles Price, and J. S. McFarlane[1] [2]

Introduction

Virus yellows is a major disease of sugar beet in Europe, and losses in some areas in years of severe infestation have been relatively high. Watson, Watson, and Hull (11)[3], from results of a series of tests in England extending from 1942 to 1952, estimated that plants infected in June and July lost up to half of their potential sugar yield. These results were confirmed by Hull (6) in replicated tests.

In the Netherlands, Hartsuijker (5) found that if infection reached 100 percent by the end of June, losses of from 25 to 30 percent of the crop occurred. Results of tests of Bjorling (2) indicate that losses may be as high as 61 percent in beets infected early in the season.

Bonnemaison (3) estimated that yellows in France may reduce root yields 30 to 40 percent and seed yields 40 to 60 percent.

In the United States virus yellows has been severe chiefly in areas where sugar beets, or other susceptible plants are present during the entire year. In some areas, notably in central California, nearly 100 percent infection occurs annually in many fields by the first of June. Planting dates in these areas are much earlier than planting dates in Europe and infection may occur at later stages of plant development. There is evidence, also, that strains of the yellows virus generally distributed in American beet-growing areas are somewhat less virulent than those prevalent in Europe.

Tests to determine losses due to yellows in the United States have given variable results. McFarlane, Bennett, and Costa (10), in one test in the Salinas Valley in 1952, found almost no reduction in tonnage but results showed a significant depression in sucrose amounting to 1.07 percent of root weight. A second test gave a highly significant reduction in tonnage of slightly more than 35 percent and a depression in sucrose of 1.11 percent of root weight.

Results from replicated plots at Riverside, California, in 1953, indicate that infection of beet plants in the 12- to 16-leaf stage, with a virulent strain of the yellows virus, produced a reduction of about 35 percent in tonnage but produced no significant depression in sucrose content (1).

In tests in Colorado in 1953, Coons, Gaskill, and Daniels (4) found that beets inoculated July 16 yielded 6.8 percent less than controls in which

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[3] Numbers in parentheses refer to literature cited.

considerable natural infection occurred. They estimated that if comparisons had been made on the basis of 100 percent infected versus 100 percent healthy plants, yields would have shown a depression in root growth of 10 to 15 percent.

Plans and Procedures

Replicated field tests were made at Riverside in 1954 and 1955 and at Salinas in 1955 and 1956, to obtain additional information on the effects of the virus yellows on sugar beet yields and sucrose content under a range of conditions.

The variety US 75 (C368) was used in all tests. Comparisons were made on the basis of inoculated and noninoculated plots. Inoculations were made by means of the green peach aphid, *Myzus persicae* Sulz. The aphids were produced on radish plants and transferred to yellows-infected sugar-beet plants 24 to 48 hours before being transferred to field plants. In making the inoculations, diseased beet leaves infested with aphids, were placed in paper bags after winged individuals had been removed. Leaves were removed from the bags in the field and small pieces, each containing about 10 aphids, were clipped off and allowed to fall on healthy plants. The leaf pieces soon wilted and the aphids moved to the beet plants. Plots were sprayed with an insecticide 24 to 48 hours after inoculation. This method of inoculation gave high percentages of infection in the inoculated plots and very little infection in adjacent rows.

Tests at Riverside. The 1954 test was made in a field planted April 29. Paired comparisons were made between plots inoculated on June 15 with a virulent strain of yellows virus (strain 2) and noninoculated plots. The pairs were replicated 14 times. The beets were harvested October 11. Yields and sucrose percentages were determined for each plot.

The 1955 test was made in a field planted April 15. A randomized split plot design with 6 replications was used. The replications were divided into 3 fertility treatments. Treatment 1 received no fertilizer. Treatment 2 received nitrogen and phosphorus at the rate of 66 lbs. N and 32 lbs. P_2O_5 per acre, applied May 31. Treatment 3 received N applied at the rate of 132 lbs. per acre and P_2O_5 at the rate of 66 lbs. per acre May 31, and a second application of N at the rate of 66 lbs. per acre July 7. In each fertility level, in each replication, one plot was inoculated with a virulent strain of the yellows virus (strain 2), one was inoculated with a strain having a low virulence (strain 6), and a noninoculated plot was retained as a control. Inoculations were made June 10. The middle 2 rows of each 4-row plot were harvested November 29 and 30. Data were obtained on yield, sucrose percentage, and purity, and on sodium, potassium, and amino nitrogen content.

Tests at Salinas. In 1955 an extensive test designed to measure the damage caused by natural infection with the yellows virus was made in an 8-acre field of beets planted December 15, 1954. The field was divided into 8 replications, each 64 rows wide and 280 feet long. Each replication was divided into 2 plots, one of which was treated with Malathion dust and the

other left untreated. The plots were arranged systematically which resulted in a checkerboard distribution of dusted and non-dusted plots. Large plots were used because it was expected that aphids would migrate from the untreated plots into the border rows of the treated plots. The treated plots were dusted at 7- to 14-day intervals, beginning shortly after the beets were thinned and continuing until the middle of July, to control aphids and reduce natural spread of yellows. Even though 18 applications of dust were made during this period, yellows infection gradually increased in the treated plots, and reached a rather high level by the end of the season. The infection was reasonably uniform throughout the plots, which made it possible to harvest small, paired, sub-plots in each replication. These sub-plots were 2 rows wide and 50 feet long and were located near the adjacent edges of the treated and untreated plots.

In a further effort to evaluate the damage caused by yellows, a second test was superimposed on the dusted areas of the test just described. This was done by laying out 3 randomized plots, each 4 rows wide and 50 feet long, near the center of each of the 8 dusted areas. One plot was inoculated with a virulent strain (strain 5) of the yellows virus March 23, shortly after the beets were thinned. A second plot was inoculated with the same virus strain May 11, when the beets reached a diameter of about 1 to 2 inches. A third plot in each dusted area was retained as a control. This provided a randomized block test with 3 treatments replicated 8 times, and was designed to measure relative amounts of damage caused by early and delayed infection with a virulent strain of the yellows virus.

Plots 2 rows wide and 50 feet long were harvested from each test on August 23. Yields were calculated and laboratory determinations made for sucrose percentage and purity, and for sodium, potassium, and amino nitrogen content. A randomized block analysis was used for both tests.

In 1956 a factorial experiment designed to test simultaneously the effects of virus strains and dates of inoculation, was conducted in a field planted December 15, 1955. Included were 6 treatments which consisted of inoculation with 2 strains of the yellows virus on 3 different dates. The 6 treatments and a noninoculated check were replicated 8 times and were randomized within the replications. The plots were 4 rows wide and 65 feet long.

The 2 middle rows of all plots, except the check plots, were inoculated. The two virus strains used were strain 5, which produces vein clearing in young leaves and marked yellowing of older leaves, and strain 3, which produces no vein clearing but causes marked yellowing of foliage. The virulence of strain 3 probably closely approximates the average virulence of yellows virus prevalent in the Salinas Valley. The inoculations were made March 26, April 30, and June 5. All plots were sprayed the day following inoculation to destroy aphids placed on the plants, and the experimental area was sprayed at 7- to 14-day intervals, from thinning through July, to reduce natural spread of yellows.

The 2 middle rows of each plot were harvested September 17. Data were obtained on yield, sucrose percentage, purity, and on sodium, potassium, and amino nitrogen content.

Results

High percentages of infection were obtained in all inoculated plots of the 4 tests. Aphid populations were very low in the tests at Riverside in 1954 and 1955, and there was very little spread of virus from inoculated to noninoculated plots. Counts of diseased plants in August of each year indicated from 80 to 100 percent infection in the inoculated plots and an average of less than 4 percent in the check plots. Clear lines of demarcation between inoculated and noninoculated plots were evident throughout the season in both years, because of foliage color differences.

Aphid populations usually are high in the Salinas Valley through late spring, summer, and Fall, and many commercial fields show a high incidence of infection by June. Application of insecticides to the experimental areas at Salinas at 7- to 14-day intervals, from shortly after thinning through July, considerably reduced and delayed infection. However, the disease spread slowly in the 1955 test during the early part of the season, and more rapidly later, reaching a high level before harvest. Aphid populations were low during the early part of the season of 1956 and check plots remained relatively free of infection until the middle of August. Spread was more rapid in late August and early September and there probably was a high incidence of infection at harvest (September 17). Distinct color differences were evident between inoculated and noninoculated plots, however, as late as the early part of September. Average percent obvious infection, on 7 dates during the season, in the check plots and plots with the different treatments, is shown in Table 1.

The results of the tests at Riverside in 1954 and 1955 are presented in Table 2, and the results of the tests at Salinas in 1955 and 1956 are presented in Tables 3 and 4, respectively. These results indicate that the yellows disease caused reductions in yield of roots varying from 13.8 to 53.0 percent of the crop, and reductions in sucrose varying from 0.42 to 2.2 percentage points. The results of the 1955 test at Salinas indicate that natural infection caused a reduction of 5.95 tons per acre, or 22.3 percent of the crop, and a reduction in sucrose content of 1.48 percentage points (Table 3).

The data from the different tests indicate that damage caused by yellows may be influenced by a number of factors, particularly level of fertility of the soil in which the beets are growing, virulence of the strain or strains of yellows virus involved, and date of infection. The effects of these factors may be considered somewhat more in detail.

Effect of Level of Fertility on Injury Caused by Yellows. Some uncertainty still exists as to the effects of fertility of soil on symptoms produced by the yellows disease, particularly the effect on foliage yellowing. Hull and Watson (7) reported that application of sulphate of ammonia to yellows-infected beets in experimental plots in England had no obvious effect in decreasing yellowing. However, they reported that commercial fields that received heavy applications of nitrogen sometimes were greener than neighboring fields that received no nitrogen.

Table 1.—Results of Periodic Counts of Diseased Plants in Tests at Salinas, California, in which Inoculations were Made with Two Strains of Yellows Virus on Three Different Dates (Field Planted December 15, 1955; Harvested September 17, 1956).

Date inoc.	Strain of virus used	Percent infection on indicated date (average of 8 plots)						
		May 1	May 23	June 6	June 20	July 3	July 18	August 16
March 26	5	97	100	100	100	100	100	100
April 30	5	7	10	90	98	99	99	100
June 5	5	7	5	6	7	69	99	100
March 26	3	66	82	84	88	90	93	96
April 30	3	8	7	80	92	96	97	99
June 5	3	9	6	8	7	17	95	99
Control	None	6	4	5	5	8	13	23

Observations thus far in California indicate that degree of yellowing is markedly influenced by level of soil fertility, particularly nitrogen level. Differences in intensity of yellowing in adjacent areas are sometimes associated with previous history of cropping of the land. Beets following legume crops are sometimes greener than those following grain crops. Often, in fields showing 100 percent infection, plants that have a space advantage in border rows, at the end of rows, or in areas of poor stands, are greener than those in other parts of the field. Application of nitrogen to diseased plants usually has resulted in partial masking of symptoms.

It seems apparent from observations and experimental results, that yellowing of infected plants in California may be less marked on plants growing at high levels of fertility than on plants growing at intermediate or low levels of fertility. However, reduced yellowing at high levels of fertility may not be highly significant with respect to damage caused by the disease. In fact, the full significance of yellowing in yield reduction remains to be determined. Tests at Riverside made in 1955 showed only a low correlation between estimated intensity of yellowing and yield, among a large number of selections. Also, comparisons of yields of 320 selections of sugar beets in tests at Salinas in 1956 revealed little correlation between yield and estimated intensity of yellowing. In both tests, some of the selections that showed least yellowing were among those showing greatest reduction in yield.

It seems probable that yields from adequately replicated plots are necessary for determination of the relationships between soil fertility levels and damage produced by the disease. Some results of this type are available from studies of yellows in England but no accurate information is available from tests in the United States. Hull and Watson (7) state that addition of fertilizers of various types increased root yield of both healthy and diseased plants, but losses, due to yellows, increased in proportion to the increase in yield. However, if increases in yield were large as a result of application of fertilizer, losses were greater than the proportional increase in yield.

The tests in 1955 at Riverside were designed to provide information on the relation of fertility of the soil to reduction in yield caused by 2 strains of the yellows virus. The results, shown in Table 2, indicated a marked increase in the yield of roots of both inoculated and noninoculated plots as fertility level was increased. The average reduction in yield of roots caused by virus strain 2, were 11.6, 10.6, and 11.6 tons per acre, or 36.8 30.1, and 30.1 percent in the low, intermediate, and high fertility plots, respectively. The average reductions in yield caused by virus strain 6 were 7.0, 6.0, and 5.3 tons per acre, or 22.2, 17.0, and 13.8 percent in the low, intermediate, and high fertility plots, respectively.

These results indicate that reduction in tonnage by the yellows disease is not necessarily proportional to yield, and that percentage loss may, in fact, tend to decrease as fertility level is increased This appears to be true particularly of losses caused by the less virulent strain (strain 6) of the virus.

Table 2.—Effect of Virulence of Virus Strain and Level of Fertility on Yellows Injury to Sugar Beet in Tests at Riverside, California, in 1954 and 1955.

Fertility level	Strain[1] of virus used	Acre yield		Sucrose	Apparent coef. of purity	Na	K	Amino N
		Gross Sugar	Beets					
		Pounds	Tons	Percent		p.p.m.	p.p.m.	Percent
Low	2	6,703	19.9	16.88	92.1	560	2,400	0.28
	6	8,177	24.5	16.78	92.2	700	2,460	0.34
	Control	10,900	31.5	17.43	92.4	700	2,330	0.30
Medium	2	7,760	24.6	15.95	89.4	910	2,290	0.43
	6	9,437	29.2	16.18	90.0	570	2,550	0.34
	Control	12,210	35.2	17.37	91.4	500	2,440	0.35
High	2	7,846	26.9	14.63	86.6	1,020	2,380	0.68
	6	9,957	33.2	15.00	87.6	840	2,380	0.61
	Control	12,180	38.5	15.82	87.8	720	2,690	0.62
High[2]	2	5,114	24.3	10.46	----	----	----	----
	Control	9,347	38.7	12.02	----	----	----	----

[1] Strain 2 is a virulent, vein-clearing strain of the yellows virus; strain 6 is less virulent.

[2] 1954 test; all other tests made in 1955.

Table 2A.—Summary of Analyses of Variance of Data for 1955 Test Shown in Table 2.

Souce of variation	Degrees of freedom	Mean-Squares						
		Gross Sugar	Beets	Sucrose	Apparent coef. of purity	Na	K	Amino N
		Pounds	Tons	Percent		p.p.m.	p.p.m.	Percent
Total	53							
Replications	5	74.5	50.6	2.1	3.6	2,011	710	9,861
Nitrogen levels	2	259.2[2]	261.2[2]	17.0[2]	109.0[2]	2,607	356	551,402[2]
Error (1)	10	29.5	13.6	0.8	2.4	833	616	16,086
Virus strains	2	2131.2[2]	574.2[2]	5.8[2]	5.9[1]	1,616[1]	892	7,786
Nitrogen levels x strains	4	5.1	2.1	0.3	1.5	1,478[1]	1,116	10,199
Error (2)	30	15.3	6.5	0.4	1.2	528	649	8,586

[1] Significant at 5% level.
[2] Significant at 1% level.

Reduction in sucrose percent was evident at all fertility levels but the results do not indicate clearly that the loss in sucrose, due to yellows, was influenced appreciably by level of fertility of the soil.

Effect of Virus Strains on Injury caused by Virus Yellows. Strains of yellows virus that range in severity of symptoms produced on greenhouse plants, from those that cause only slight yellowing on old leaves to those that cause marked vein clearing on young leaves and marked yellowing and necrosis on older leaves, have been found both in Europe and the United States. Comparative effects of different strains under field conditions have not been studied extensively. However, Ludecke, Schlosser, and Nitzsche (9), in Germany, found that variants of the yellows virus of different degrees of virulence, produced different effects on yield and chemical composition of sugar beets.

To obtain additional information on the influence of degree of virulence of yellows-virus strains on yield and chemical composition of the sugar beet, experiments were conducted at Riverside in 1955 and at Salinas in 1956, in which attempts were made to measure relative effects of selected virus strains. All strains were isolated from sugar beets grown in California.

The test at Riverside was made at three levels of fertility with two virus strains (strains 2 and 6). Strain 2 is a highly virulent, vein-clearing strain, and strain 6 is one of the least virulent strains available for test. Plots were inoculated June 12 and yellows symptoms began to appear first on plants inoculated with the more virulent strain. Obvious infection with strain 2 reached 95 percent by July 2, whereas obvious infection with strain 6 ranged from 70 to 90 percent on that date. Early in the season, yellowing was obviously more intense in plots inoculated with strain 2 than in plots inoculated with strain 6, at the medium fertility level, but differences in the effects of the two strains were less marked at the low and high fertility levels. However, differences increased as the season progressed and by the latter part of August it was possible to distinguish plots inoculated with the respective strains at all levels of fertility.

In the test at Salinas in 1956, in which inoculations were made on three different dates, two virus strains were used. One strain (strain 5) was highly virulent and the other strain (strain 3) had a medium degree of virulence. As in the Riverside test, symptoms appeared first on the plots inoculated with the virulent strain. Yellowing was more intense throughout the season in plots inoculated with strain 5 than in plots inoculated with strain 3. Also there appeared to be more dwarfing of tops in plots inoculated with strain 5. Some of the differences in degree of yellowing caused by strains 5 and 3, 45 days after inoculation, are shown in Figure 1.

Further results of these tests are shown in Tables 2 and 4. In the Riverside test, reductions in root weight caused by strain 6 were only 60.3, 56.6, and 54.7 percent of those caused by strain 2 at the low, medium, and high levels, respectively. In the Salinas test, reductions in root weight by strain 3 were 54.3, 86.4, and 76.3 percent of those caused by strain 5 in the respective three dates of inoculation.

Figure 1.—Beet field used in the tests at Salinas in 1956. In the foreground are two rows (left) inoculated with virus strain 5; two noninoculated rows (middle); and two rows (right) inoculated with virus strain 3. Plots were inoculated March 23 and photographed May 10.

Both strains of the virus produced significant reductions in sucrose percent at all fertility levels in the Riverside test, but there was no clearly defined differences between the effects of the two strains in this respect. However, in the Salinas test, reduction in sucrose percent was significantly greater with strain 5 than with strain 3 in plots inoculated March 26 and June 5. The results in plots inoculated May 11 are confused somewhat by the fact that the inoculum used on this date was a mixture of strain 3 and a more virulent strain of the yellows virus.

The results with respect to purity, and sodium, potassium, and amino nitrogen content, are not uniformly clear but where changes appear to be produced, as in decreases in purity and increases in sodium and potassium, they appear to be smaller with the less virulent virus strain in each test. (Table 4 and 4A.)

The results of these two tests indicate clearly that virulent strains of the yellows virus produce greater reductions in root weight, and probably in sucrose percent, than less virulent strains. Since the virulence of the virus strains used in these tests was judged originally on the basis of severity of symptoms produced on greenhouse plants, it seems probable that the capabilities of virus strains for production of injury in the field may be estimated with a reasonable degree of accuracy from severity of symptoms produced on small plants growing under glass.

Table 3.—Effects of Date of Inoculation and Natural Infection on Yellows Injury to Sugar Beet in Tests at Salinas, California, in 1955. (Inoculations made with virus strain 5)

Treatment of plots	Acre Yield		Sucrose	Apparent coef. of purity	Na	K	Amino N
	Gross Sugar	Beets					
	Pounds	Tons	Percent		p.p.m.	p.p.m.	Percent
Inoc. March 23	5,234	17.1	15.33	89.68	198	2,022	0.34
Inoc. May 11	6,900	22.8	15.13	93.10	199	1,781	0.30
Control (sprayed)	8,200	26.1	15.75	93.76	204	1,863	0.31
L.S.D. (5%)	444[2]	0.4[2]	0.43[2]	NS	NS	112[2]	NS
Natural exposure	5,548	19.6	14.06	89.96	301	1,915	0.33
Control (sprayed)	7,946	25.6	15.54	92.53	212	1,976	0.31
L.S.D. (5%)	665[2]	1.1[2]	1.13[1]	NS	NS	NS	NS

[1] Significant at 5% level.
[2] Significant at 1% level.
NS—Not significant.

Table 4.—Effects of Virulence of Virus Strain and Date of Inoculation on Yellows Injury to Sugar Beet in Tests at Salinas, California, in 1956.

Date of inoculation	Strain of virus used[1]	Acre-yield		Sucrose	Apparent coef. of purity	Na	K	Amino N
		Gross Sugar	Beets					
		Pounds	Tons	Percent		p.p.m.	p.p.m.	Percent
March 26	5	4,876	16.1	15.18	90.0	240	2,210	0.33
April 30	5	6,050	20.1	15.03	90.8	260	2,080	0.31
June 5	5	8,352	26.3	15.90	91.1	210	2,010	0.28
March 26	3	7,318	22.6	16.15	91.3	190	2,090	0.30
April 30	3	6,630	21.5	15.40	91.3	260	2,020	0.30
June 5	3	8,864	27.3	16.21	92.1	190	1,960	0.24
Control	None	10,470	30.4	17.23	91.2	130	2,060	0.25
L.S.D. (5%)[2]		452	1.2	0.40	1.1	34	134	NS

[1] Virus strain 5 is one of the more virulent strains of the yellows virus and strain 3 is of medium virulence, as judged by effects of these strains on beets under greenhouse conditions.

[2] The control plots were omitted in the statistical analysis of the data.

Table 4A.—Summary of Analyses of Variance of Data Shown in Table 4.

Source of variation	Degrees of freedom	Mean Squares						
		Gross suger	Beets	Sucrose	Apparent coef. of Purity	Na	K	Amino N
		Pounds	Tons	Percent		p.p.m.	p.p.m.	Percent
Total	47							
Replications	7	0.18857[1]	6.62[1]	0.45[1]	49.23[2]	540[2]	5.384[1]	.0042
Dates of inoculation	2	7.66869[2]	249.61[2]	2.85[2]	4.17[1]	1,450[2]	11,330[2]	.0118
Strains	1	4.16718[2]	108.00[2]	3.68[2]	10.27[2]	800[1]	9,330[1]	.0093
Dates x strains	2	1.19923[2]	37.92[2]	0.54[1]	0.69	220	565	.0008
Error	35	0.04954	1.36	0.15	1.13	109	1,738	.0054

[1] Significant at 5% level.
[2] Significant at 1% level.

Effect of Age of Plant at Time of Infection on Injury Caused by Yellows. It would be expected, of course, that plants infected with yellows virus when young would be more severely damaged than plants infected in later stages of development. Watson, Watson, and Hull (11), in England, estimated that reductions in yield amounted to from 3 to 5 percent for each week the plants showed obvious symptoms of yellows.

Hartsuijker (5) states that in The Netherlands, losses ranged from 4 to 5 percent per week in total weight of sugar during the period plants were infected.

Ludecke and Nebb (8), in Germany, found that early infection caused proportionately greater losses than later infection. In plots harvested October 26, sugar yields of plants inoculated in mid-May were reduced 53.8 percent, whereas late August infection caused virtually no decline.

Age of plant at the time of infection was a factor in tests at Salinas in 1955 and 1956. In the test in 1955, infection in the 12- to 16-leaf stage resulted in average reductions in weight of roots of 9.0 tons per acre, or 34.1 percent. A delay of 49 days in inoculation, at which time the plants had roots 1 to 2 inches in diameter, resulted in a reduction in weight of roots of 33.28 tons per acre, or 12.5 percent (Table 3).

In the test in 1956, in which three dates of inoculation with two virus strains were used, losses decreased markedly as infection was delayed, as shown in Table 4. The trend is especially evident with the virulent strain 5, and in the first and third inoculation with strain 3. The discrepancy in yield in the second inoculation with strain 3 is believed to be due to the use of a mixed inoculum on this date.

The average daily losses in root weight per ton, from the time of inoculation to harvest, were calculated in the two experiments and are shown in Table 5. The calculated daily losses are, of course, somewhat less than the actual daily losses, due to the fact that they are calculated on the

Table 5.—Average Daily Loss in Yield of Sugar Beets Caused by Yellows Virus Strains 3 and 5 in Tests at Salinas, California.

Date inoc.	Time from inoc. to harvest (Days)	Reduction in yield (Tons per acre)		Reduction in yield per day of infection (Pounds per acre)	
		Strain 3	Strain 5	Strain 3	Strain 5
1955 Test:					
March 23	153	.....	9.0	.....	11.1
May 11	104	.....	3.3	.....	6.3
1956 Test:					
March 26	175	7.8	14.3	8.9	16.3
April 30[1]	140	8.9	10.3	12.7	14.7
June 5	104	3.1	4.1	5.9	7.8

[1] The strain 3 virus used in this date of inoculation was found to have been contaminated with a more virulent vein-clearing strain. This may account for the relatively high reduction in yield in plots inoculated with strain 3 on this date.

basis of yield of check plants in which there was some reduction in yield due to yellows. However, it is not believed that damage to check plots, particularly in the 1956 test, was sufficient to distort appreciably the calculated differences. The results tend to indicate that not only was damage less as infection was delayed, but also that average daily reductions in root weight tended to decrease with delay in infection.

The percent sucrose was lower in beets of both dates of inoculations than in the controls in the 1955 test and significantly lower than the controls in all of the three dates of inoculation in the 1956 test. However, the results do not indicate that date of inoculation in these tests markedly influenced the percent sucrose reduction caused by yellows. This is especially true with the less virulent strains.

Summary

Tests at Riverside and Salinas, California, in 1954, 1955, and 1956 indicated that when infection with the sugar-beet yellows virus occurred in the 12- to 16-leaf stage of plant development, yellows caused reductions in weight of beet roots ranging from 13.8 to 53.0 percent. Sucrose content of beets was reduced in all tests. Reductions ranged from .42 to 2.2 percentage points. Under some conditions, but not under all, there was a slight but significant reduction in purity, and an increase in sodium and potassium content. There was no influence on amino nitrogen content.

Natural infection in replicated plots at Salinas in 1955 resulted in a reduction in root weight of at least 22.3 percent and an average reduction in sucrose percent of 1.38 percentage points.

The amount of injury produced by yellows was influenced by vigor of the plant, virulence of the strain of virus involved, date of infection, and probably other factors

Plants growing in highly fertile soil usually showed less intense yellowing of foliage than plants growing in soil of intermediate or low fertility. Application of nitrogenous fertilizers to diseased plants usually was followed by partial masking of yellowing. Tonnage losses were higher in plants growing at high fertility levels but losses due to yellows were not proportional to increase in yield. Reduction in sucrose percent by the yellows disease was not significantly different at the different fertility levels used.

Weight of roots was markedly influenced by virulence of the strain of yellows virus involved. In tests at Riverside in 1955, a strain of high virulence caused reductions in weight of roots of 36.8, 30.1, and 30.1 percent, respectively, at three levels of soil fertility, whereas corresponding weight reductions with a strain of low virulence were 22.2, 17.0, and 13.8 percent. In tests at Salinas in 1956 a virulent strain of virus reduced root weights 47.0, 33.9, and 13.5 percent, respectively, in three dates of inoculation, whereas, the corresponding weight reductions by a strain of medium virulence were 25.7, 29.3, and 10.2 percent. Reduction in sucrose percentage appeared to be correlated with degree of virulence of the strain of virus involved.

Age of the plant at the time of infection had an important bearing on the amount of damage produced. Inoculation of plants in the 12- to 16-leaf stage in tests at Salinas in 1955 resulted in a reduction of 34.1 percent in root weight, whereas inoculation 49 days later resulted in a reduction in root weight of only 12.5 percent. Similar results were obtained with two strains of virus and three dates of inoculation in tests at Salinas in 1956. Daily reductions in weight of roots, calculated on the basis of reduction in weight over the period from inoculation to harvest, tended to decrease with age of plant at the time of infection.

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Proprietary Materials for Acceleration of First Carbonation Thickening

N. D. Hill and F. G. Eis[1]

A paper, "Further Experiences with Algins" was presented at the eighth general meeting of this society by Halden and Moore. (1)[2] The paper reviewed Spreckels' experiences with Kelgum, a sodium alginate product of the Kelco Company, as a settling aid for first carbonation sludge.

The use of Kelgum as a settling aid has continued at the Spreckels factories. The benefits have been positive and results satisfactory under normal operating conditions. However, for abnormal operating conditions such as processing of muddy beets, and infrequently under apparently normal operating conditions, a cloudy Dorr overflow may be encountered.

To insure that an aid more effective than Kelgum would not be overlooked, a laboratory scale investigation of the effectiveness of various commercially available settling aids was conducted during the 1955 spring campaign. The aids tested include the following:

Settling Aid	Supplier
Kelgum	Kelco Company
Aerofloc 548	American Cyanamid Co.
Aerofloc 552	American Cyanamid Co.
Aerofloc S-3059	American Cyanamid Co.
Lytron X886	Monsanto Chemical Co.
Duolite Polyelectrolyte 503-6A	Chemical Process Co.
Separan 2610	Dow Chemical Co.

This paper presents an evaluation of these settling aids with respect to Dorr thickener capacity, overflow clarity, effect of detention time in the thickener, optimum rate of addition to first carbonation juice, and dispersion characteristics.

Experimental Procedure and Results

Tests were made by the Dorr-Kynch method as described by Talmage and Fitch (2). The calculations were modified to give results in units of capacity per unit area rather than unit area required. The Dorr-Kynch method has been found to be less time-consuming than the Skaar-McGinnis (3) modification of the method of Coe and Clevenger. The results of the Dorr-Kynch method appear to be as valid as those obtained by the Skarr-McGinnis method.

The settling aids were dispersed in water at a concentration of 0.1% and were added to the factory first carbonation juice at a rate of 1 to 5 p.p.m. Figure 1 is a typical settling curve used for the calculation of settling capacity.

All of the aids listed above were tested during the first part of the investigation. After several series of tests, Aerofloc 552, Aerofloc S-3059, Separan 2610, and Duolite 503-6A were eliminated from further testing.

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[2] Numbers in parentheses refer to literature cited.

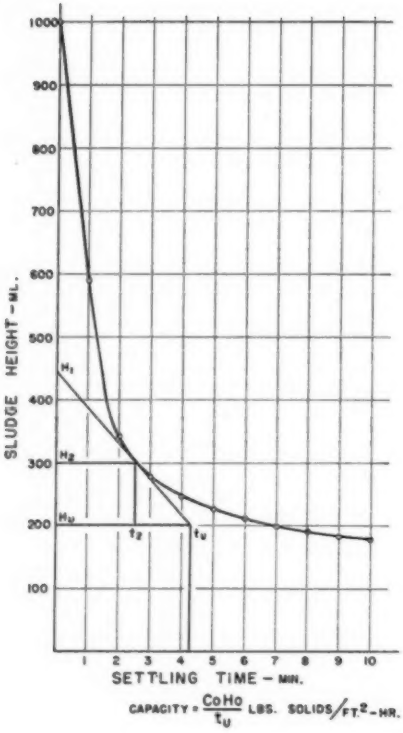

Figure 1.—Thickener capacity by Dorr-Kynch method.

These aids consistently produced lower capacities and in most cases did not give a sparkling clear effluent. The rest of the tests were made using the three remaining settling aids with Kelgum for a basis of comparison.

Two p.p.m. appeared to be the optimum rate of addition for all aids under normal operating conditions. When the rate of addition was increased above this value, the rate of settling was found to decrease slightly. With additions at a lesser rate a cloudy effluent was frequently encountered.

Tests were made on first carbonation juice during a period of cloudy Dorr overflow due to excess mud being brought into the factory with the beets. Aerofloc 548, when added at the rate of 4 p.p.m. was the only one of the aids tested on this juice that produced a clear effluent. The other aids produced effluents of varying degrees of cloudiness. It had been planned to test this aid on a factory scale under similar conditions during the 1955 fall campaign, but the opportunity was not forthcoming as no difficulties were encountered with a cloudy Dorr overflow.

Table 1.—Average Thickener Capacities with Settling Aids

Settling Aid	Quantity Added P.P.M.	Capacity Lbs. solids/sq. ft.-hr.
Kelgum	2	34.9
Aerofloc 548	2	34.6
Lytron X886	2	25.9
No settling aid	0	24.4

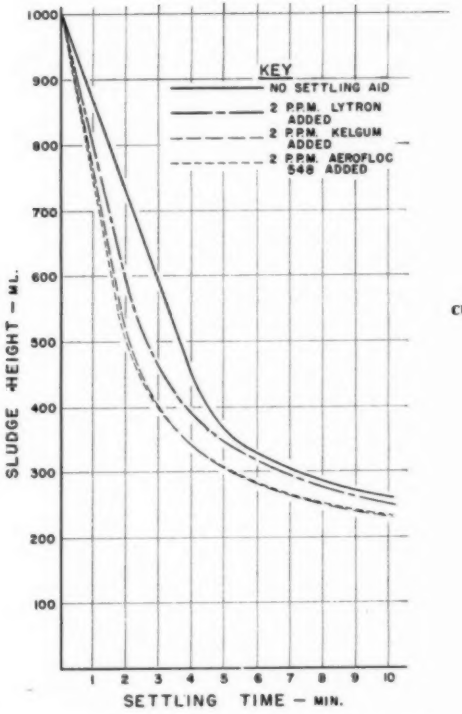

Figure 2.—Typical settling curves.

The average capacities for the aids tested are listed in Table 1. The aids, tested during the first portion of the series only, are not included as the results are considered to be unimportant. Kelgum and Aerofloc 548 when added at the rate of 2 p.p.m. produced the highest capacities and showed approximately equal effectiveness for normal operations. Lytron X886 showed only slightly higher capacities than were obtained without settling aids. Figure 2 illustrates a typical set of settling curves obtained using the settling aids listed in Table 1.

A series of tests were made using an hour contact time between the settling aids and the first carbonation juice, to determine the effect of detention time in the Dorr thickener. Kelgum and Aerofloc 548 gave slight increases in capacity and Lyton X886 gave an equivalent decrease. Halden and Moore (1) previously showed this effect with Kelgum. These observations indicate that when using these aids, one could expect little change in settling characteristics due to detention time in the Dorr thickener.

The dispersibility of the settling aids was found to vary considerably. Hot water is deemed a necessity for dispersion of Kelgum as it will not completely disperse in cold water. Although Aerofloc 548 and Lytron will disperse in cold water, they will do so more readily in hot water. When Kelgum was dispersed in cold water, the optimum rate of addition was 4 p.p.m. as compared to 2 p.p.m. for a hot water dispersion. The effectiveness of the other aids in a cold water dispersion was not determined. However, to insure complete dispersion and maximum efficiency, all of the settling aids should be dispersed in hot water.

Conclusions

The tests reported in this paper indicate that:

1. Kelgum and Aerofloc 548, both at 2 p.p.m., produced the fastest settling rates. They showed approximately equal effectiveness in settling first carbonation sludge under normal operating conditions.
2. Aerofloc 548 at 4 p.p.m. was the only aid that produced a clear effluent when a high silt content was encountered in the first carbonation juice.
3. The settling rate of first carbonation sludge should show no significant change due to detention time in the Dorr when using the aids tested.
4. Complete dispersion of the settling aids is necessary for maximum effectiveness. The aids were found to be most readily dispersible in hot water.

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Chemical Weed Control in Some Holly Areas in Montana, Colorado, and Wyoming

E. M. Holst, E. G. Eckroth, C. E. Cormany[1]

Interest in chemical weed control over the past five years has been increased by the synthesis of several new chemicals which seem to offer considerable promise for controlling weedy plants in sugar beets. During 1954 and 1955, a number of these chemicals at several rates, applied both pre- and post-emergence were tested in the Intermountain Area with various results.

Two tests at Swink, Colorado, in 1954 with sodium dalapon at rates varying from 2.3 to 10.5 pounds of sodium dalapon per acre were conducted. The highest rate of sodium dalapon gave no reduction of percent sucrose, but such a reduction, if it existed, may have been masked by the presence of nematode and root rot which reduced stands from 92 beets per hundred feet of row after thinning to 31 by harvest time.

The second test was on late planted beets and included rates of 4.7, 5.9 and 7.1 pounds per acre of sodium dalapon. Included as checks were hand-weeded and unweeded zero rates. At time of application, grasses present (*Echinochloa crusgalli, Setaria* spp. and *Eragrostis cilianensis*) were stooling, beets were in the six- to eight-leaf stage and temperature was about 85° F. No effect was noted on the beets due to application at this high temperature. All rates except zero gave excellent control of barnyard grass and foxtail. Apparently little lovegrass (*E. cilianensis*) was not affected. Harvest data showed no significant differences in yield or percent sucrose due to treatment. Stands of beets between treatments were comparable. The treatments were replicated in a Latin square design.

Table 1.—Effect of Post-Emergence Treatment with Sodium Dalapon and E.H.6249 (Sodium Trichloropropionate) on Visually Estimated Vigor of Sugar Beet and Grass Seedlings at Swink, Colorado, 1955.

Treatment	Vigor of Beets*	Vigor of Grasses*
1. Check — No Treatment	2.5	1.0
2. Check — Hand-weeded	2.9	1.3
3. 5 Pounds Per Acre Sodium Dalapon	2.9	4.3
4. 7 Pounds Per Acre Sodium Dalapon	3.0	4.9
5. 5 Pounds Per Acre E.H.6249	3.4	2.3
6. 7 Pounds Per Acre E.H.6249	2.7	3.6
Calculated F for Treatment	1.00 NS	27.04**
LSD (.05)	NS	0.88
LSD (.01)	NS	1.18

* Vigor scale 1-5, 1 being most vigorous, 5 being dead.
** Significant at 1% level.

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During 1955, E.H.6249 (sodium trichloropropionate) and sodium dalapon were used on seedling beets (cotyledon stage). Temperature was about 85° F. Grasses present in very large numbers, flagleaf stage, were *E. crusgalli* and *Setaria* spp. Observations two weeks after application showed no difference in vigor of the beet seedlings. Rates of 5 and 7 pounds per acre of sodium dalapon and E.H.6249 were used. Vigor of the grasses was considerably reduced, the heavier rate of sodium dalapon being most effective. No significant differences in vigor of beets were observed.

At Sheridan, Wyoming, during the extremely dry spring season of 1954, chemical treatments of many kinds showed little or no effect on the control of early grasses and broadleaf weeds. However, pre-planting application of DCU, IPC, and TCA, when disced or harrowed into the soil, gave some control. For grass control the results are not significant statistically, probably because of the extreme variation in the amounts of grasses present from plot to plot throughout the field. The data do show much lower populations for the treatments than for the checks. No harmful effect was noted on the sugar beet seedlings.

Table 2.—Weed Control by Pre-Planting Applications of Chemicals. Sheridan, Wyoming—1954.

Treatment	Weeds per Sq. Ft. Area	
	Grasses	Broadleaf
1. DCU — 7 lbs./A — Disced 4" deep	3.85	4.08
2. DCU — 14 lbs./A — Disced 4" deep	1.40	2.22
3. IPC — 4 lbs./A — Disced 4" deep	1.70	6.32
4. TCA — 7 lbs./A — Harrowed lightly	.70	3.02
5. Check — No treatment	6.12	7.78
General Mean	2.76	4.68
LSD (.05)	NS	1.94

Predominating weeds present were barnyard grass (*E. crusgalli*), wild oats (*Avena fatua*), foxtail grass (*Setaria* spp.), pigweed (*Amaranthus retroflexus*), lambsquarter (*Chenopodium album*), and mallow (*Malva* spp.).

Pre-emergence and post-emergence trials with three herbicides were conducted at Hardin, Montana, during 1955. Because of flooding just prior to harvest, yield data were not secured, but samplings were made to determine sucrose content of the beets. Weed counts made in mid-June along with other pertinent data, appear in Table 3.

Fair control of grasses was obtained with both chemicals and with both post-emergence and pre-emergence applications. Beets were not stunted by dalapon at 3 pounds and E.H.6249 at 6 and 12 pounds. However, beets were sunted by dalapon at 4 and 8 pounds with recovery satisfactory. This may have retarded their growth enough to counteract any possible increase in yield due to grass control. Predominating weeds are the same as those reported at Sheridan, Wyoming.

Table 3.—Effect of Post- and Pre-Emergence Treatment with Dalapon and E.H.6249 on Percent Sucrose of Sugar Beets and Control of Weeds at Hardin, Montana, 1955.

Treatment	Rate Lbs./A.	Percent Sucrose	Percent Stand	Weeds Per 1 Sq. Ft.[1]	
				Grasses	Broadleaf
1. Check	0	16.36	77	41	12
Pre-Emergence:					
1. Dalapon	3	16.42	82	13	8
3. E.H.6249	6	16.58	80	11	9
4. E.H.6249	12	16.36	73	8	7
5. DCU	14.6	15.94	81	12	8
Post-Emergence:					
6. Dalapon	4	15.84	73	19	12
7. Dalapon	8	16.40	72	21	5
8. E.H.6249	2	16.34	77	25	12
9. E.H.6249	4	16.25	78	30	18
10. E.H.6249	6	16.52	75	23	8
General Mean		16.30	77	20	9
LSD (.05)		NS	NS	9.1	4.8

[1] Counts taken in oblong 4" wide by 36" long in beet row.

From post-emergence trials conducted at Sidney, Montana, in 1954 with dalapon and endothal, it appeared that only dalapon showed much promise in controlling wild oats (*A. fatua*). Pigeon grass (*Setaria* spp.) was also controlled, but control of *A. fatua* is of more importance to farmers in this area. Dalapon at 3 and 6 pounds per acre acid equivalent gave excellent control of both grasses but seemed to stunt beets temporarily. Endothal had no effect on either beets or grasses.

In 1955, dalapon and E.H.6249 were used. Results are shown in Table 4.

Table 4.—Effect of Post-Emergence Treatment with Dalapon and E.H.6249 on Yields, Percent Sucrose, Purity, and Stands of Sugar Beets in 1955 at Sidney, Montana.

Treat.	Acid Equiv.	Tons Beets Per Acre	Percent Sucrose	Lbs. Sugar Per Acre	Percent Purity	Stand	Wild Oats Per Sq. Ft.[1]
Dalapon	3	15.490	18.92	5864	93.98	78	2.3
Dalapon	4	15.914	18.67	5948	94.18	81	2.4
Dalapon	5	15.363	18.47	5672	93.55	81	2.1
Dalaphon	6	14.991	18.10	5429	94.12	79	2.0
Dalapon	7	15.304	17.72	5421	94.15	78	2.1
E.H.6249	3	14.692	13.95	4094	94.42	78	3.2
E.H.6249	4	14.617	14.57	4260	94.18	80	3.0
E.H.6249	5	14.687	11.27	3315	94.18	79	2.7
Check	—	15.313	18.82	5881	94.33	80	16.3
LSD (.05)		NS	1.15	490	NS		
LSD (.01)		NS	1.55	663	NS		

[1] Average of ten counts per treatment.

Both dalapon and E.H.6249 gave excellent control of wild oats. Dalapon burned the beet leaves at rates of 4, 5, 6 and 7 pounds, whereas E.H.6249 showed no burning. Dalapon at 3 pounds did not burn the beet leaves and gave almost as good grass control as the higher rates. E.H.6249 appeared to be much less severe on the sugar beets but yet had some effect on yield reduction, although not significant, and had a very definite effect on sucrose. Table 4 illustrates the extent to which E.H.6249 lowered the sucrose content. This was very surprising as the beets showed no burning or any unusual visible effect. This needs further checking. Purity as measured by the oxalic titration method (1) [2] was not affected by these treatments.

During both 1954 and 1955, temperature appeared to play an important part on effectiveness of dalapon. Warm temperatures cause dalapon to work much faster. It is interesting to note also that the early stunting of the sugar beets by dalapon during both years did not affect yield. Dalapon in 1954 stunted beets extremely at rates above 3 pounds. This was evidenced by elongation and thickening of the beet leaves.

In summary, sodium dalapon, post-emergence application, at rates of 2.3 pounds per acre to 10.5 pounds per acre was used successfully in the Intermountain Area to control grassy weeds in sugar beets. Weeds controlled include *A. fatua, E. crusgalli,* and various species of *Setaria.*

Rates above 4.4 pounds of sodium dalapon per acre seem to have some temporary adverse effect on beets, at least in the six- to eight-leaf stage. Warm temperatures at Swink, Colorado, were not as severe in accenting this stunting effect as warm temperatures at Sidney, Montana. Pre-emergence application of sodium dalapon at three pounds per acre yielded control.

E.H.6249 at rates varying from 2 pounds per acre to 6 pounds per acre post-emergence gave significant and practical control of grasses mentioned above, but in one case, percent sucrose was markedly lowered. However, at Hardin, Montana, an even higher rate of application did not reduce percent sucrose.

Pre-emergence application of E.H.6249 at rates of 6 to 12 pounds per acre controlled grasses and reduced broadleaved weeds by about 40 percent.

DCU, at 14.6 pounds per acre significantly lowered grassy weeds at Hardin, Montana. However, at Sheridan, Wyoming, DCU, at 7 and 14 pounds per acre did not reduce grassy weeds, although broadleaved weeds were significantly reduced.

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Exploratory Studies on the Use of Paper Chromatography and Electrophoresis for Detection of the Yellows Virus in Sugar Beet[1]

MERLE G. PAYNE, JOHN O. GASKILL, JESS L. FULTS, AND LESLIE B. DANIELS[2]

Virus yellows is generally considered to be the most serious virus disease of sugar beet (*Beta vulgaris* L.) in western Europe where it has been an important problem for many years (18)[3]. Definite evidence of its occurrence in the United States was reported by Coons (4, 5) in 1952. His results show that the disease was widespread at that time, and he stated that it probably had existed in this country as early as 1940—possibly much earlier. Published reports of damage appraisal studies conducted in 1952 and 1953 (2 ,6, 15) and unpublished results of more recent studies (3, 10) have shown conclusively that the disease causes substantial losses in root yields and sucrose percentages in parts of Colorado in certain years, and that it is especially serious in parts of California.

In virus disease studies, particularly in breeding for resistance, a positive means of identifying virus-infected plants is highly desirable. Symptoms in sugar beet more or less resembling those of virus yellows may result from various nutritional and other environmental conditions. Furthermore, individual plants or inbred strains may be essentially symptomless carriers. In Europe, such factors have led to extensive use of a serological test for detection of the virus in sugar beet plants (4). A positive reaction from such a test is generally accepted, by Europeans familiar with the method, as proof of virus yellows infection. A negative reaction is considered as inconclusive since a relatively high concentration of the virus in the plant is required to give a positive reaction.

A recent review of the present status of procedures for determination of the presence of viruses in plant juice extracts has been made by Pirie (17). Two general techniques have been developed—serological determination and assay by physico-chemical methods. Serological determination, although highly specific, is estimated to be in error 30 percent of the time. Physico-chemical techniques have been developed for relatively few viruses—notably tobacco mosaic, potato virus X, and a few others. All physico-chemical techniques so far suggested depend on determination of the protein or nucleic acid that remains in a system after impurities have been re-

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The authors especially wish to thank Grace Yasuda Chiang, Mary Klinger, and Grace W. Maag for their assistance in the laboratory phases of this investigation.

[3] Numbers in parentheses pertain to list of references.

moved by some fractionation procedure. None of these techniques appears adapted to plant viruses which occur in low concentration, and it is apparent that either entirely new approaches or improvements in old ones are needed. Two new methods involving paper chromatography and electrophoresis show promise. These techniques have been suggested by Gray (13), by McAnelly et al. (14), and Fife (7).

The studies reported in this paper were undertaken in order to investigate the possibility of utilizing paper chromatography or electrophoresis for detection of the sugar beet yellows virus. The work has been exploratory in nature and has not as yet led to the development of a proven testing procedure. However, it is felt that the results obtained thus far may be of interest to others working in this field.

Methods

Sugar Beet Strains and Field Methods

In 1954 a number of sugar beet strains were grown in 1-row, 45-foot plots in a field near Fort Collins, Colorado, chiefly for virus yellows resistance comparisons. Rows were spaced 40 inches apart in order to promote symptom development and to facilitate yellows reaction readings. Stands were thinned to approximately 12-inch spacing in the row. During the 2-day period, June 21-22, all plants in a 20-foot section of row in each plot were exposed to inoculation by means of green peach aphids (*Myzus persicae* Sulz.) which had been reared on yellows-infected sugar beet plants, a comparable 20-foot section in each plot serving as a control sub-plot. The yellows virus or yellows virus complex involved was representative of that naturally occurring in commercial fields in northern Colorado. Techniques employed in rearing the aphids and in applying them to the plants in the field were similar to those described for a yellows experiment conducted at Fort Collins in 1953 (6). The entire experimental area was sprayed frequently with Parathion, beginning on June 25 and ending September 3. Aphid control by this means was relatively satisfactory, yellows being confined almost entirely to the inoculated sub-plots where susceptible strains approached 100 percent obvious infection. Mosaic was not a factor.

Late in September, three inbred strains, representing a wide range in apparent reaction to virus yellows, were chosen for special study. McFarlane 3502 (now NB1) was classed as resistant; US 201-B (53126-0), intermediate; and 461020, highly susceptible. As used in this paper the terms resistant, intermediate, and susceptible pertain only to degrees of yellowing caused by the virus and do not necessarily indicate comparable degrees of resistance to other virus effects.

On September 28, three composite leaf samples, representing old, medium, and young leaves, respectively, were taken from apparently healthy plants of each of the three inbreds in the control sub-plots—a total of nine samples, each based on 10 plants. The term, "old," as used here, refers to outer leaves, not senile; youngest leaves, approximately fully expanded, were classed as "medium" and leaves classed as "young" were only about one-fourth as large as the medium age group. A comparable set of nine

composite samples was composed of leaves from plants in the inoculated sub-plots presumed to be infected with virus yellows. In the intermediate and susceptible strains, plants definitely infected were chosen. In McFarlane 3502, in which both percentage and intensity of symptom expression were very low, the presence or absence of symptoms was disregarded. The 18 leaf samples were placed in separate plastic bags, closed tightly, quickly frozen, and subsequently stored at approximately —17° C.

Yellows comparison plots, similar to those described above, were set up in 1955 with only minor deviations in timing and technique, but with essentially a new set of sugar beet strains. Late in October, seven strains were chosen for chromatographic use. This set consisted of one commercial variety (Acc. 1359, GW 359) and six inbreds, two of which were among those used for such studies in 1954. Two of the seven strains were classed as susceptible (461020 and 54323); two as intermediate, Acc. 1359 and US 201-B (Acc. 2013); and three as resistant (Accessions 1264, 1344, and 2005). On October 31, 1955, leaf samples were taken from each strain in about the same way as in the preceding year, with two exceptions: (1) the age class was medium; and (2) presence or absence of yellows symptoms was disregarded entirely. In regard to the latter, it should be stated that, as in 1954, susceptible strains such as 461020 showed a high percentage of obvious yellows infection in the plants of the inoculated sub-plots and only a very small percentage of such plants in the non-inoculated sub-plots, indicating relatively satisfactory virus transmission and aphid conrol.

Laboratory Methods

Paper Electrophoresis

A Wieland type of electrophoretic instrument, modified by Grassmann and Hannig (11), was used to produce zone electrophorograms. The pH of the cacodylic buffer[4], which served as the electrophoretic electrolyte, was adjusted to 6.93, just above the isoelectric point of the beet protein, so that the protein fraction moved anodically. The ionic strength was 0.1.

The frozen beet leaf samples were thawed and the juice dialyzed with distilled water under constant stirring for four hours to eliminate the sugars and free amino acids. Then the samples were lyophylyzed to concentrate them 12 to one. A 5-microliter aliquot of the juice, dialyzed and concentrated 12 to 1, was pipetted near one end of a buffer-dampened filter paper strip (Whatman No 1) one and one-fourth inches wide. The instrument was run six hours at 300 volts and five milliamperes, after which the paper

[4] Cacodylic Buffer:
4. 68 g. of sodium chloride
4.28 g. of sodium cacodylate
0.46 g. of cacodylic acid
Dissolved in enough water to make one liter.

[5] Dye bath
2.5 g. of amido black 10 B
450.0 ml. of acetone-free absolute methanol
50.0 ml. of glacial acetic acid

strips were taken out and put immediately (that is, without drying) into a bath of amido black 10 B[5] (Farbenfabriken, Bayer Leverkusen, Germany) for 10 minutes, where they were dyed a dark color. Three 10-minute baths of 5-percent phenol were used to destain the strips of paper, followed by fixation in 10-percent concentrated glacial acetic acid in absolute methanol. The strips then were dried, leaving the protein zones with a dark blue color.

The relative amounts of proteins in the leaf juices were measured by passing the dried electrophorograms through a densitometer (Welch and Company Densichron) at 3 mm. intervals followed by plotting the optical density data on graph paper. Since the amount of amido black 10 B adsorbed is directly proportional to the amount of protein on the paper (12), the optical density curves were used to compare healthy and diseased samples.

Paper Chromatography

Ascending one-dimensional paper chromatography was used, as described by Williams and Kirby (20). Small sheets (20 x 20 cm.) of Whatman No. 1 filter paper were used. The solvent was 40-percent ethyl alcohol. Twenty microliters of 12:1 concentrated juice were placed on the paper, dried, and chromatographed in a closed container at constant temperature. After the solvent had ascended the paper, the paper was removed and put immediately, that is without drying, into a dye bath of amido black 10 B, fixed and destained as described for the electrophorograms.

These one-dimensional chromatograms of the leaf proteins were used both years to determine the maximum optical density of the principal protein and the R_f (the distance the protein travels up the paper divided by the distance the solvent travels up the paper) of the principal protein.

The sugar attached to the leaf proteins was determined by cutting out, of the one-dimensional chromatograms, the principal protein spot of the healthy and yellows-infected material. These pieces of filter paper, containing the principal protein spot, were placed in separate test tubes and hydrolyzed with 1 ml. of 1 N H_2SO_4 for 2 hours at 100° C. A 10-microliter portion was chromatographed in a solvent containing a mixture of 4 parts of butanol, 1 part of glacial acetic acid, and 2 parts of water. When the solvent front approached the top of the paper, the paper was removed and dried until all odor of the solvent had dissipated. The paper then was sprayed with Partridge's aniline hydrogen phthalate reagent (16) and, after subsequent drying, was developed at 120° C. for 15 minutes.

Two-dimensional paper chromatography was carried out according to the techniques described by Franklin *et al* (8, 9). A 0.1 M. sucrose solution and 0.1 M. sodium potassium tartrate solution were used as the two solvents. One drop of Tween 81 was added to 1 ml. of the concentrated beet juice before placing 20 microliters on Whatman No. 1 paper. The juice spot was allowed to dry on the paper before the latter was placed in the first solvent. After removal from the second solvent, sodium potassium tartrate, the papers were dyed immediately in amido black 10 B as previously described.

Results and Discussion

Electrophorograms

Figure 1 shows typical zone electrophorograms from two healthy and two yellows-infected sugar beet sub-plots in 1954. Medium size leaves were used in each case. This was done because, by experiment in 1954 with young, medium, and old leaves, it was found that the difference between healthy and diseased samples was greatest in medium leaves. The principal movement in the electrophorograms was toward the anode and shows a definite increase in total proteins in the yellows-infected samples.

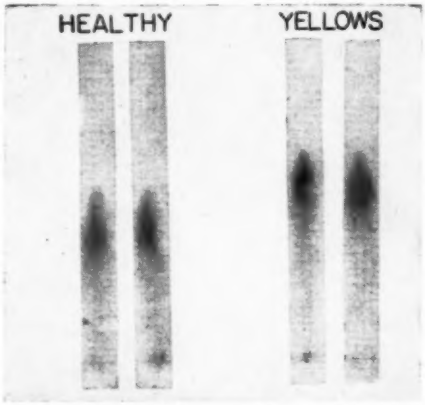

Figure 1.—Typical electrophorograms from leaf juice of healthy and yellows-infected sugar beet plants, 1954.

The electrophorograms were read on the densitometer and graphed. In Figure 2 typical optical density curves are shown. It can be seen from these curves that the main protein component of the healthy plants is present in a decreased amount in the yellows-infected sugar beets. This decrease in amount of the normal protein with increase in a different protein fraction, in the yellows samples, is in agreement with Wildman *et al* (19) and Gray (13).

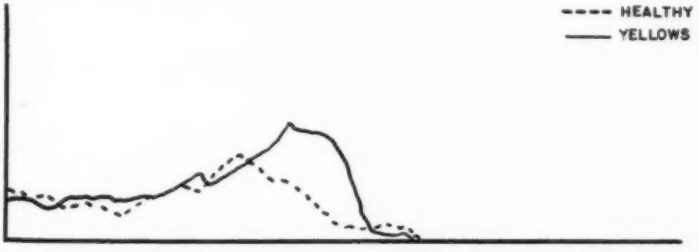

Figure 2.—Typical optical density curves from electrophorograms showing the protein fractions of healthy and yellows-infected sugar beet leaf juice. Curves were obtained by plotting optical density readings from paper electrophorograms against distance moved, cathode at left, anode at right.

This new protein Wildman found to be infective. The new fraction in our electrophorograms has not been proved to be the virus. Such proof might be difficult to obtain because of the nature of its transmission.

One-dimensional Chromatograms

Figure 3 shows typical contrasts between healthy and yellows-infected sugar beet plants for the principal protein fractions in 1-dimensional chromatograms of medium leaves in 1954 and 1955. The developing solvent used was 40-percent ethyl alcohol. This concentration of alcohol was selected following a series of tests in which the percentages of alcohol used were 20, 30, 40, 50, 60, and 70 respectively. The main protein fraction did not move

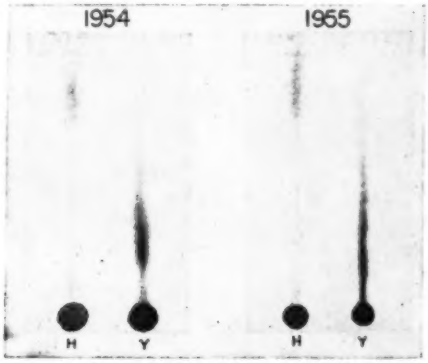

Figure 3.—Typical one-dimensional chromatograms of leaf juice from healthy and yellows-infected sugar beet plants, 1954-1955.

Table 1.—Effects of virus yellows in old, medium, and young leaves, on the maximum optical density of R_f of the principal protein in sugar beet plants, 1954.

Variety		Age of	R_f		Optical Density	
Classification	Number	Leaves	Healthy	Diseased	Healthy	Diseased
Resistant	3502	Old	0.42[1]	0.36	1.58	1.76
		Medium	0.34	0.10	1.87	2.00
		Young	0.44	0.50	1.91	1.97
Intermediate	53126-0	Old	0.15	0.15	1.31	1.55
		Medium	0.48	0.26	1.30	1.71
		Young	0.49	0.36	1.55	1.89
Susceptible	461020	Old	0.33	0.12	1.62	1.77
		Medium	0.57	0.13	1.36	1.91
		Young	0.49	0.57	1.30	1.19

[1] Each value is average of duplicate determinations.

at 70-percent in either healthy or virus-infected samples. There was slight movement at 20-percent. Best movement for comparative tests appeared to be 40-percent. Gray (13) observed a similar phenomenon.

The greatest differences in the R_f, between healthy and yellows samples in 1954, appeared in the medium leaves. In 1955 only medium leaves were used. The data for both years are shown in Tables 1 and 2, and bargraphs of the data in Figures 4 and 5. These results show that the R_f for medium leaves was lower in the yellows samples for all strains in both years.

Table 2.—Effects of virus yellows on the R_f and maximum optical density of the principal protein in sugar beet leaves, 1955.

Variety		R_f		Optical Density	
Classification	Number	Healthy	Diseased	Healthy	Diseased
Resistant	Acc. 1344	0.34[1]	0.18	1.68	1.89
	Acc. 2005	0.50	0.32	1.74	2.18
	Acc. 1264	0.66	0.20	1.10	1.65
Intermediate	Acc. 1359	0.54	0.47	1.53	1.56
	Acc. 2013	0.62	0.54	1.29	1.39
Susceptible	461020	0.54	0.42	1.50	1.80
	54323	0.54	0.39	1.47	1.70

[1] All samples are from medium leaves. Each value shown is the average of duplicate determinations.

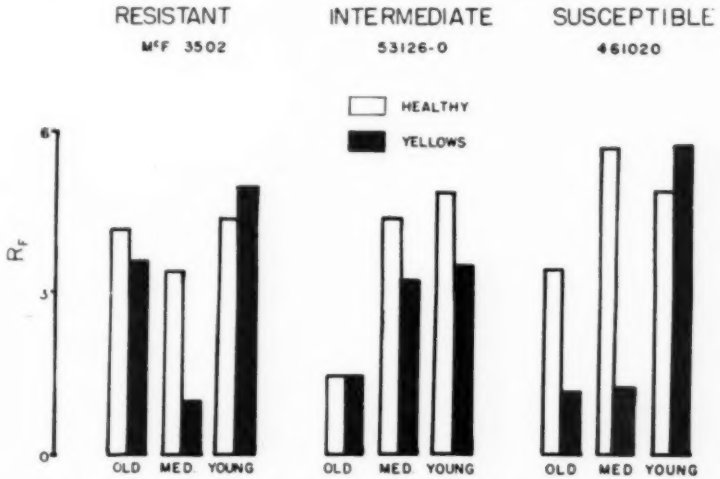

Figure 4.—Histograms comparing the R_f of the principal protein in old, medium, and young leaves of healthy and virus-infected sugar beets, 1954. Each value shown is the average of 8 chemical determinations.

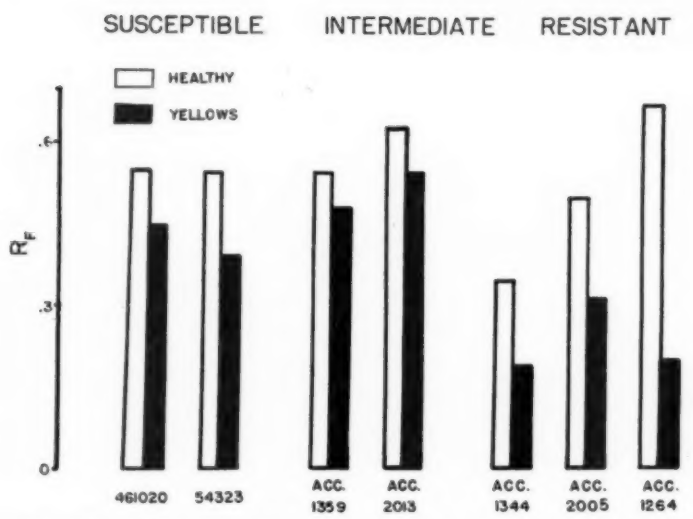

Figure 5.—Effects of virus yellows on the R_f of the principal protein in medium-age sugar beet leaves, 1955. Each value is the average of duplicate determinations.

The maximum optical density of the principal protein was greater in the yellows samples for old, medium, and young leaves in 1954, than in healthy samples, except for the young leaves in the susceptible variety. For the medium leaves in 1955, the optical density, for all strains, was greater in the yellows samples than in the healthy samples. Tables 1 and 2 show the data and Figures 6 and 7 the bargraphs.

In studying curly top in sugar beets, Fife (7), using 1-dimensional paper chromatography, found striking differences in the relative concentration of certain amino acids. The change that was found in the proteins of yellows-infected beets is not in disagreement with Fife's work.

In Figure 8 comparable chromatograms are shown for a mixed sugar sample containing D-glucose, D(-)-ribose, and 2-deoxy-D-ribose, and for healthy and yellow-infected sugar beet samples. The protein spot cut out of 1-dimensional sugar beet chromatograms and hydrolyzed showed a glucose spot in both samples from the hydrolysis of the paper (compared to paper controls). The sugar hydrolyzing from the protein appeared to be ribose and was more concentrated in the yellows samples.

The increase in ribose in the hydrolyzed protein samples from virus-infected sugar beets may be due to an increase in virus ribonucleoprotein. If so, it would agree with the results of Wildman *et al* (19). They used electrophoretic scanning diagrams and showed that tobacco mosaic virus increases at the expense of normal protein. Presumably this virus follows the known pattern of several other plant viruses (1) of multiplying in functional tissue where cell division is at a minimum (medium leaves).

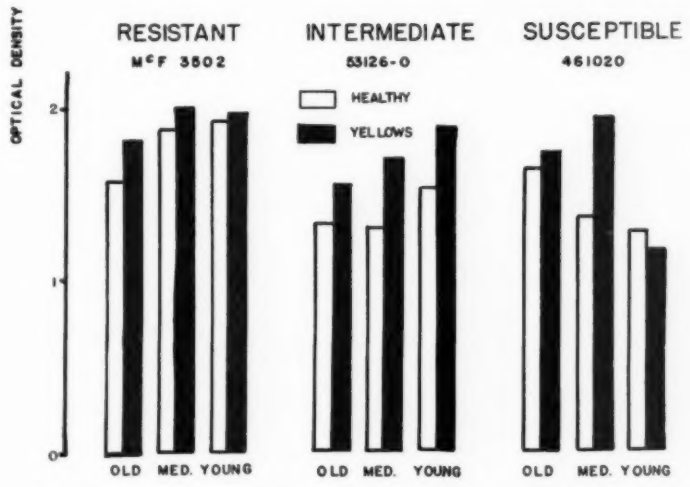

Figure 6.—Histograms comparing the maximum optical density of the principal protein in old, medium, and young leaves of healthy and virus-infected sugar beets, 1954. Each value shown is the average of 8 chemical determinations.

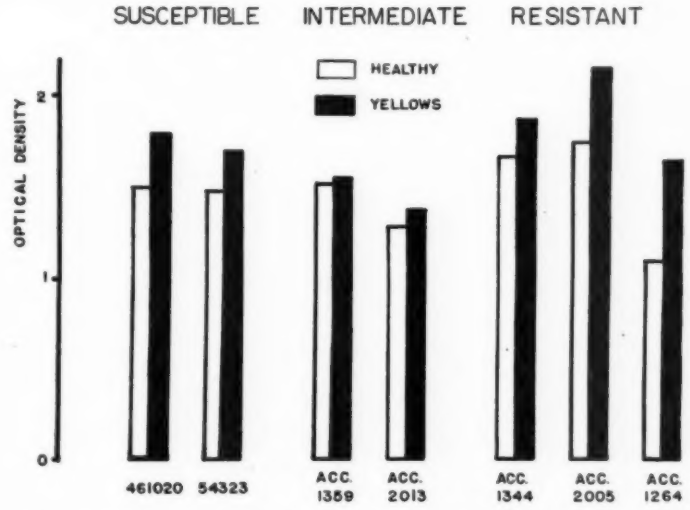

Figure 7.—Effects of virus yellows on the maximum optical density of the principal protein in medium-age sugar beet leaves, 1955. Each value is the average of duplicate determinations.

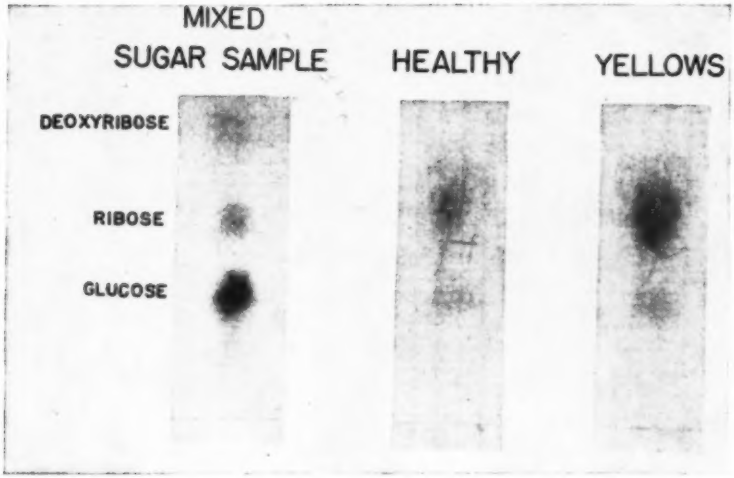

Figure 8.—Typical one-dimensional chromatograms, showing the sugar attached to the principal protein of leaf juice from healthy and yellows-infected sugar beet plants. (Glucose spot is from hydrolyzed filter paper.) The position of pure glucose, ribose, and deoxyribose is also shown for a mixed Sample.

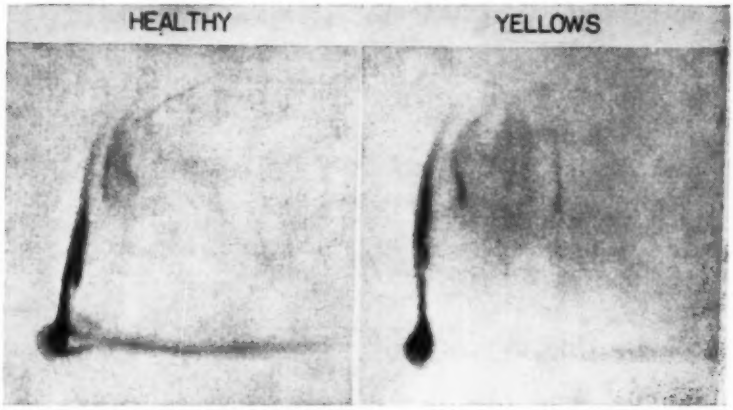

Figure 9.—Typical two-dimensional chromatograms from leaf juice of healthy and yellows-infected sugar beet plants.

Two-dimensional Chromatograms

Two-dimensional chromatograms of healthy and yellows-infected sugar beet samples are shown in Figure 9. It is noted that the number of protein fractions from the healthy sample is less than from the yellows-infected sample. In 1954, 2-dimensional chromatograms were run for all medium-leaf samples. The number of protein fractions for the healthy plants averaged 4.20, and 6.42 for the yellows-infected plants. Here again, whether or not one or more of these new fractions in the yellows infected samples is actually virus protein has not been proved.

Summary

Leaf juice samples from healthy and virus yellows infected plants of eight sugar beet strains which differed widely in apparent reaction to the disease were compared by chromatographic and electrophoretic techniques. The studies were exploratory in nature, and the results were not subjected to statistical analysis. However, certain definite trends were observed. Those trends were most pronounced for medium-age leaves and may be summarized, for that age class, as follows:

1. In zone electrophorograms, the main protein fraction in the diseased samples moved anodically at a substantially faster rate than in the healthy controls.
2. In 1-dimensional paper chromatograms, prepared with 40-percent ethyl alcohol as the solvent, the diseased samples, as contrasted with the controls, were consistently (a) lower in R_f of the main protein fraction; (b) higher in maximum optical density of that fraction; and (c) higher in amount of D(-)-ribose in hydrolyzed protein.
3. In 2-dimensional paper chromatograms, the diseased samples averaged 6.42 protein fractions and the healthy samples, 4.20.

On the basis of these results, chromatographic or electrophoretic techniques appear promising as means of detecting the presence of the yellows virus in sugar beet plants. However, before definite conclusions in this regard can be made, population studies are needed. Such studies should include both infected and healthy plants, representing a relatively wide range of sugar beet genotypes, with the chemical determinations performed on an individual-plant basis.

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Developments of First Carbonation Vacuum Filter Details

G. W. Miles, Jr.[1]

Introduction

The evolution of various methods of separating first carbonation sludge is no doubt well known to most of you. Development in the industry has moved through the plate and frame stage, pressure filter stage utilizing Kelley-type filters, and thence into a vacuum filter stage. The vacuum filter stage has included such combinations as Genter or Borden tube type vacuum filters followed by a suitable rotary vacuum filter to desugar the resulting sludge; and the more or less standard combination of utilizing a thickner or clarifier for initial sludge separation, followed by a rotary type vacuum filter. This paper is concerned principally with the recent developments and practices in the use of rotary type vacuum filters for reclaiming the dissolved sugars from this first carbonation sludge.

Procedure

Naturally, most of the initial developments were concentrated in improving the automatic valve head. This phase of development resulted in the present valve head with three separate sections—the filtrate or initial cake section, the wash or cleansing section, and the discharge or blow section. In view of the fact that this development is well established a review will be concentrated on developments for: (1) Protective coatings, (2) types of drainage grids and the adaptation of new type grids to old vacuum filters, and (3) a few methods of dressing the filters.

The problem of protective coatings to lengthen the life of the drums and metal parts of the filter has long been a subject of much controversy and varying methods. Almost everyone has utilized the clean and oil method to lengthen the life of the filters. However, this is a continuing expense and proper cleaning and oiling each season requires considerable labor, and costs about $.045 per square foot per year. This method does not offer complete protection to the drums, and an average steel filter drum so treated will probably require replacement after 25 years of service, involving a drum replacement cost of about $1.40 per square foot per year. Total drum maintenance then becomes about $1.45 per square foot per year.

Recently there has been developed a series of plastic paints which, if properly applied, appear to give a very durable protective coating. Tygon and Plasite are two examples of these protective coatings. The Plasite which has been used on vacuum filter drums is No. 7100 cold set. This is a material composed of thermo-setting phenolic resins modified with a small percentage of Epoxy resin, plasticizers, solvents, inert pigments, and a liquid alkaline catalyst.

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The procedure for applying this type of protective coating is to first sandblast the unit, clean up the sand, apply the initial primer, and then apply multiple coats of Plastie No. 7100. It is recommended that at least two coats be applied to give a thickness of .012 to .015 of an inch. The curing time is four to five days at about 70° F. and, with this type of coating, protection is afforded in corrosive conditions of temperatures up to 400° F. The initial cost for such an application is about $1 per square foot and, assuming a five-year life, this then represents $.20 per square foot per year. The additional drum life by the use of protective coatings is not known, but initially it would appear to be economically sound and certainly is a step in the right direction.

There are several other similar protective coatings that are suitable for varying temperatures and various types and strengths of corrosive elements, but it appears that Plastie No. 7100 will work out very well for use on first carbonation vacuum filters. The coverage for this material is about 40 to 50 square feet per gallon, and it can be applied wih a standard spray gun by the average sugar factory painter.

Figures 1 and 2 are pictures of a rotary vacuum filter to which this protective coating has been applied. This drum is equipped with perforated screen type grids, and has been in operation about 100 days since the application of the protective coating.

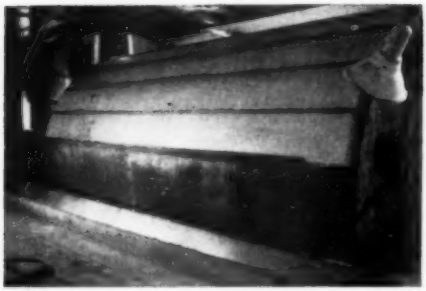

Figure 1.—General view of Plasite coated vacuum filter (perforated screen grids).

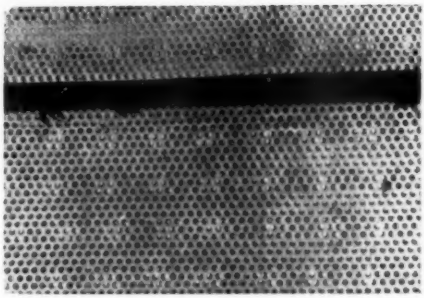

Figure 2.—Close-up view of Plasite coated drum and perforated screen.

The development of drainage grid details has also progressed through various stages, including wooden slats, wire screens, flat perforated screens (held in place by a strap, gasket and countersunk bolts), and snap-in screens, to mention a few. In recent years the perforated screen, either flat or snap-in, has been the most common.

However, the requirement of replacing this type grid periodically has been expensive in both labor and material, approximately $.67 per square foot per year on a six-year life basis. Filter manufacturers have made frequent and continuing revisions toward a more durable and suitable type drainage grid. One of the latest types is the hard rubber drainage grid which is depicted in Figure 3, a sketch projection of one grid section. Figure 4 is a picture of a rotary vacuum filter equipped with rubber grids

Rubber grids are furnished in sections 24 inches long, and in widths from 15 inches and 18 inches to fit the customer's filter. To modify a vacuum filter with screen type drainage grids to accomodate rubber grids, it is necessary first to remove the old screens, marcells, and division bars. When these are removed and the bolt holes, if any, are welded up, all welds and chisel marks are ground smooth and any spatter resulting from the welding is removed. At this stage, the drum should be bare and smooth and the existing drum heads (to which nothing has been done) should project about 1 inch above the drum.

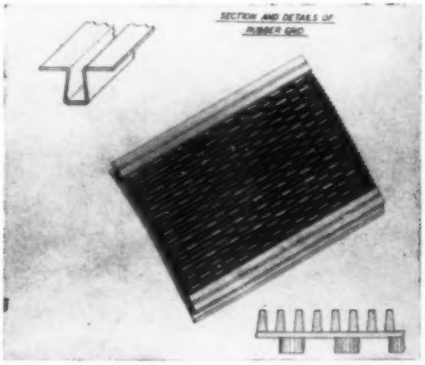

Figure 3. — Sketch projection and details of rubber grid section.

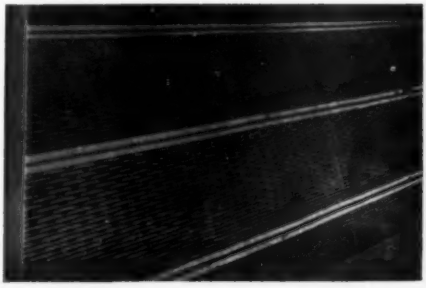

Figure 4.—Old style vacuum filter modified to the use of rubber drainage grids.

Next, the stainless steel grid clips shown in Figure 3, are welded to the drum in the position of the previous division bars. These are welded solid on the trailing edge of the clip and spot welded on the leading edge. This seals between the divisions, and gives strength to both sides of the clip. There is apt to be some warping of old drums from this welding as can be noted in Figure 4. The ends of the clips are seal welded to the drum heads. At this point the drum should be sandblasted and covered with a suitable protective coating as discussed previously.

To insert the grid section in the divisions it is necessary to warm the grids in water at 75° to 80° C. This makes the grid flexible and it can be bent along the long axis and inserted between the grid clips. The section is then pressed in place by hand to form to the contour of the drum. When the rubber grid cools a little, it again becomes rigid and retains the contour.

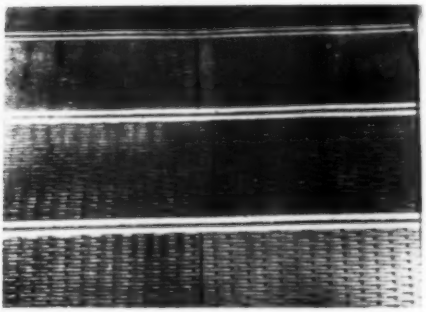

Figure 5. — Close-up of staggered grid sections.

To prevent a continuous joint in the grid sections around the drum (into which a wrapping wire could sink), the sections are staggered between divisions. Figure 5 indicates this staggering which is accomplished by starting every other division with a slightly shorter section on each end. The final result is a good substantial drainage grid which supports the filter medium. This modification complete with grids installed and a suitable protective coating costs about $7.30 per square foot. Allowing $6.30 per square foot for the grid installation alone, the break-even life of the rubber grids as compared to bolted screens would be between 9 and 10 years. It seems reasonable to assume that the rubber grids will last at least this long in carbonation service.

The grid clips are designed to permit either wrap dressing or panel dressing which represents the last phase in this discussion of recent developments. It has long been the custom to attach the filter medium to this type of rotary vacuum filter by means of seal wraps on each end and about 1⅛ inch spaced wire wrap across the face of the drum. In recent years some effort has been placed on eliminating the wire wrapping and utilizing a system of panel dressing across each division.

In panel dressing, the filter medium is attached to the drum by means of rubber or fiber rope which is caulked into grooves in the division strips. The cloth is sealed at the ends of the drum by wire wrap or steel band. No other wrapping is used, except that one or more steel bands may be placed around the drum to control billowing of the cloth during blowoff. In this type of dressing the cloth billows and bears against the discharge apron during blowoff. This action is said to clean the cloth more thoroughly than does the blowoff with conventional wire wrapping. This type of dressing is being used quite successfully in a comparatively difficult magnesium hydroxide operation near Salinas.

Experience has shown that panel dressing offers no marked advantages in carbonation filtration. The cleaning cycle was not markedly effected. On the other hand, the cloth life was shortened and labor requirements for dressing increased as compared to normal wire wrap dressing. It has been found that it takes about 2½ times as many man-hours to panel dress as it does to wire wrap a filter and this represents about $.057 per square foot more in labor alone.

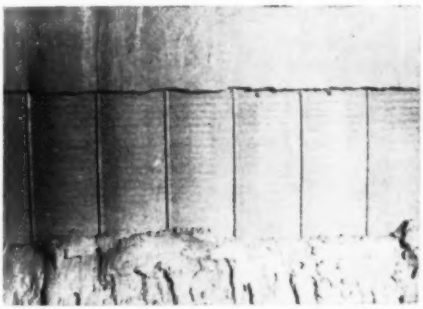

Figure 6. — 4-inch spaced wrap on rubber grid equipped filter.

Figure 7. — 4-inch spaced wrap on perforated screen grid equipped filter.

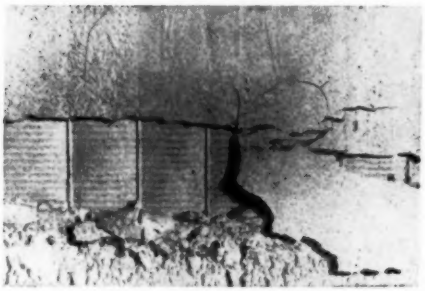

Figure 8. — 4-inch spaced wrap on rubber grid equipped filter.

A recent modification of wire wrapping has been found to be economical and beneficial. This involves the usual seal wraps on both ends but utilizes a four inch spaced wrap across the face of the drum. Figures 6, 7, and 8 show units in operation with four inch spaced wraps on rubber grids and on perforated screens, using cotton style No. 15 mesh cloth. Besides saving labor, his type of dressing reduces shutdown time for dressing by about 50 percent as compared to the normal 1⅛ inch spacing, and lowers the labor cost per dressing by about $.017 per square foot of area covered. The four inch type of wide wrap dressing has several advantages in (1) less wire requirements, (2) more filter media exposed, (3) better filter qualities, and (4) no apparent unsatisfactory "blow-by."

Summary

To summarize, three phases of recent developments in first carbonation vacuum filter details have been covered:

1. Protective coatings to lengthen the life of the filters. In this regard it is noted that there are various plastic-type paints that could be suitably applied at a cost of about $1 per square foot. The benefits are: (1) Longer life of the unit, (2) less maintenance, and (3) no continuing cleaning and oiling costs. The length of life for these protective coatings is still a guess, but certainly a 100-day campaign indicated no major problem.

2. New type drainage grids appear to be a better support for the filter media with improved drainage area. They can be adapted to old style filters at a cost of about $7.30 per square foot including protective coating, and thus far the maintenance requirements for replacement of broken grids, etc., average about ½ of one percent of the screen-covered surface, or about $.017 per square foot per year.

3. The methods of dressing rotary filters which included the normal wire wrap at about 1⅛ inch spacing, panel-type dressing and wide wrap dressing at about 4 inch spacing. For first carbonation filtration the latter method has been found satisfactory and economical.

A Preliminary Report on the Use of Gibberellic Acid to Hasten Reproductive Development in Sugar Beet Seedlings[1]

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In genetic studies and breeding work with sugar beets, *Beta vulgaris* L., the length of the life cycle frequently is an important factor limiting the rate of progress. A method announced by the author in 1952 (1, 2)[3], involving prolonged photothermal treatment of young seedlings, now is being used by a number of sugar beet research workers in the United States as a means of hastening reproductive development. With strains or varieties of sugar beets having ordinary or average bolting tendencies, the complete life cycle, from seed to mature seed, can be produced satisfactorily in six months—two such cycles, successively, within a year—by means of this method. However, techniques for reducing still further the time required for the life cycle would be highly desirable, particularly for bolting-resistant types.

Recent studies by numerous investigators have shown that reproductive development of certain types of plants is hastened considerably by the application of gibberellic acid and related substances. No attempt will be made to review the reports of those studies, but certain observations are of special interest. Marth, Audia, and Mitchell (6) summarized their findings regarding floral response in a wide variety of plants as follows: "There was no evidence that gibberellic acid could induce plants to initiate flower primordia. Accelerated stem elongation was, however, sometimes accompanied by relatively rapid flower development compared with that of untreated plants. Treated pepper plants, on the other hand, remained vegetative longer and flowered 30 days later than did controls. Elongation of seed stalks of beet plants was stimulated, but it is not known at this time whether seed production was accelerated." Wittwer and Bukovac (7) found that flowering of various types of plants, including some biennials, was hastened considerably by application of gibberellins. Remarkable stem elongation was observed on gibberellin-treated sugar beets, not exposed to cold, but apparently flower buds had not appeared on those plants by the time their report was prepared. Lang (4), working with the biennial, *Hyoscyamus niger*, concluded that gibberellin appeared to replace primarily the cold requirement of that plant for floral development, but not the long-day requirement.

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[3] Numbers in parentheses pertain to list of references.

A preliminary experiment started at Fort Collins, Colorado, in September, 1956, indicated rather strongly that gibberellic acid[4] could serve to materially hasten reproductive development in young sugar beet seedlings if used in conjunction with photothermal-induction treatment. Results regarding timing of gibberellic acid applications were not conclusive, but pointed toward the advisability of making those applications after the period of photothermal treatment rather than before or during that period.

Methods

The results presented in this report were obtained entirely from the bolting-resistant inbred, NB1[5]. The photothermal-induction treatment employed, involving continuous incandescent illumination, without sunlight, and continuous low temperature (approximately 45-46° F.), was similar to that described in an earlier report (2). Except for such periods of induction, all plants were kept in a greenhouse throughout the duration of this study. The seedlings were started in 3-inch pots, thinned to 6 per pot, and transferred to 6-inch pots (as 6-plant clusters) before crowding became noticeable. Planting of seed and induction treatments were so timed that the groups of seedlings representing the different induction exposures were nearly the same size on January 8, 1957, the date when all induction treatments were concluded and the first applications of gibberellic acid were made. Gibberellic acid was prepared for use as an aqueous solution (1,000 p.p.m.), with the aid of ethyl alcohol and liquid detergent, as suggested by Marth, Audia, and Mitchell (5). It was applied as a foliar spray, almost to the point of run-off.

Up to January 8, incandescent light was provided in the greenhouse for 4 hours in the middle of each night. All-night light was provided, from that date forward, as previously described for the post-induction period (2)[6]. Except as otherwise indicated, moderately warm greenhouse conditions were maintained, temperatures averaging approximately as follows: 9:00 a.m. to 4:00 p.m., 77° F.; 7:00 p.m. to 8:00 a.m., 57°; over-all, 65°.

Two experiments of an exploratory nature were conducted. Different lengths of induction treatment were included in each experiment. In addition, two post-induction temperature levels were compared in Experiment 1, and different numbers of applications of gibberellic acid were compared in Experiment 2. In the former, half the plants were held from January 8 to February 25 in a greenhouse room in which day and night temperatures were approximately 19° and 10°, respectively, lower than those described in the preceding paragraph. Additional details regarding methods are given in Tables 1 and 2.

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[4] The gibberellic acid used in the Fort Collins studies reported in this article was furnished, as experimental samples, by Merck and Company, Rahway, New Jersey.

[5] Developed by J. S. McFarlane, Geneticist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Salinas, Calif., for use in areas where a high degree of resistance to bolting is a necessity for satisfactory commercial sugar beet production.

[6] For convenience, the term, "post-induction period," is used in this report to designate the entire period from the conclusion of the exposure to continuous cold and continuous artificial light until the end of the study. It is recognized that induction probably occurred to some extent during that time, especially in the cool greenhouse room.

Table 1.—Effects of Gibberellic Acid on Bolting and Flowering of Sugar Beet Seedlings, at Two Temperatures, Following Varying Photothermal-Induction Treatments; Experiment No. 1.

Date seed planted (1956)	Photothermal induction		Gib. acid appl.[a]	Warm[b]				Cool[b]			
					Plants with stalks 5/10/57[c]				Plants with stalks 5/10/57[c]		
	Days	Dates (1956-57)		Total Plants	Total with Stalks	Reproductive type	Flowering[d]	Total Plants	Total with Stalks	Reproductive type	Flowering[d]
	No.		No.	No.	No.	No.	No.	No.	No.	No.	No.
12/18	0	—	0	12	0	0	0	12	0	0	0
do	0	—	4	12	12	0	0	12	12	0	0
12/6	21	12/18-1/8	0	12	0	0	0	12	0	0	0
do	21	do	4	12	12	4	4	11	11	8	7
11/15	43	11/26-1/8	0	12	4	4	4	12	6	4	2
do	43	do	4	12	12	11	11	12	12	12	12

[a] Dates of application: 1/8, 1/22, 2/5, and 2/22/57

[b] "Warm" and "cool" pertain to greenhouse temperatures during the 7-week period beginning 1/8/57. Over-all average temperatures for the two rooms during that period, based on thermograph charts, were approximately 65°F and 51°F., respectively. Thereafter, all plants were held in the warm room.

[c] Stalks less than 1 inch high disregarded.

[d] Reproductive-type plants on which opening of flowers had begun by 5/10/57.

Table 2.—Effects of Photothermal Induction and Gibberellic Acid on Bolting and Flowering of Sugar Beet Seedlings; Experiment No. 2.

Date seed planted (1956)	Photothermal induction		Gib. acid applications				Total Plants	Plants with stalks 5/9/57[a]		
	Days	Dates (1956-57)	Number	Dates (1957)				Total with Stalks	Reproductive type	Flowering[b]
				1/8	1/22	2/5				
	No.						No.	No.	No.	No.
12/18	0	—	0				12	0	0	0
do	0	—	3	x	x	x	11	11	0	0
12/6	21	12/18—1/8	0				12	0	0	0
do	21	do	1	x			12	0	0	0
do	21	do	2	x	x		12	12	1	0
do	21	do	3	x	x	x	11	11	2	2
11/15	43	11/26—1/8	0				12	3	2	0
do	43	do	1	x			11	8	3	1
do	43	do	2	x	x		12	12	10	9
do	43	do	3	x	x	x	12	12	9	9

[a] Stalks less than 1 inch high disregarded.

[b] Reproductive-type plants on which opening of flowers had begun by 5/9/57.

Results

A progress report on Experiment 1 was given at the twenty-eighth annual meeting of the Colorado-Wyoming Academy of Science, Fort Collins, Colorado, April 13, 1957, based on plant classifications made on March 28 (3).

Representative pots of certain treatments in the warm-room set of material belonging to Experiment 1 are shown in Figure 1. Striking effects of gibberellic acid, in promoting reproductive development, are shown in pot D, contrasted with pot C. Both had been given 43 days' photothermal induction. Pot D subsequently had received four applications of gibberellic acid; pot C, none. At the time the photograph was taken (March 16), 11 of a total of 12 plants, represented by D, had reproductive-type seed stalks and four were flowering. On the other hand, no stalks were apparent on the 12 comparable plants represented by C.

Figure 1.—Response of seedlings of a bolting-resistant sugar beet strain (NB1) to photothermal induction and gibberellic acid; 6 plants per pot in 6-inch pots. Induction time, in days, and numbers of gibberellic acid applications, respectively, were as follows: A- 0, 0; B- 0, 4; C- 43, 0; D- 43, 4. Arrow points toward tip of a vegetative stalk. Photograph was taken March 16, 1957 (Experiment No. 1).

Early effects of gibberellic acid, without the aid of photothermal induction, are illustrated in pot B, Figure 1. At that time, short stalks were

evident on all 12 such plants, and all those stalks tentatively were classed as vegetative in type. Pot A had received neither photothermal induction nor gibberellic acid. As expected, the 12 plants in the experiment, represented by A, were without stalks. The vegetative type stalks resulting from gibberellic acid treatment, without photothermal induction, are shown more clearly in pot B, Figure 2, August 1, 1957.

Final plant classification data for Experiment 1 are summarized in Table 1. Three points are of particular interest: (a) Gibberellic acid obviously stimulated the development of reproductive type stalks, where preceded by photothermal induction, but failed to show such effects without the aid of induction. (b) Forty-three days' induction, where followed by gibberellic acid, appeared to be essentially adequate for satisfactory reproductive development, but inadequate where gibberellic acid was not used. (c) The fact that cool greenhouse conditions did not appear to be necessary for satisfactory reproductive development, where 43 days' induction plus gibberellic acid were provided, is of special importance to the sugar beet breeder because of practical considerations.

On May 10, 1957, approximately 25 weeks after date of planting, all seed was harvested from each of the 11 plants classed as reproductive in

Figure 2.—Response of sugar beet seedlings to gibberellic acid without photothermal induction; same plants as A and B in Figure 1; photographed August 1, 1957. Note the vegetative-type stalks on the plants receiving gibberellic acid (B).

type in Table 1, warm room, with 43 days' induction plus gibberellic acid. Fully matured seed balls occurred on each plant, and some were near the shattering stage. Germination tests made in steamed soil showed satisfactory viability for the seed obtained from each of the 11 plants. Seed lots obtained by enforced selfing, in paper bags, were about equal to the open-pollinated lots in viability. Average germination for all lots was approximately 88 percent.

It is known that the bolting-resistant strain used in this study (NB1) normally requires considerably more than 43 days' photothermal induction for subsequent satisfactory reproductive development, and well over 6 months' total time for production of the complete life cycle. Consequently, the outcome of Experiment 1, in showing satisfactory results for only 43 days' induction, where gibberellic acid was used, with the mature seed crop harvested in less than 6 months from date of planting of the original seed, represents a significant advance in the development of sugar beet breeding techniques.

The results for Experiment 2 are presented in Table 2. Because of crowded conditions and relatively severe shading which arose in this experiment within a few weeks after gibberellic acid treatments were begun, the numbers of reproductive-type individuals shown in the table are thought to be somewhat lower than normally could be expected, and variability in response is considered greater than usual for such inbred material. Consequently, these results should be viewed with caution. It is of interest to note that the general pattern of gibberellic acid stimulation of reproductive development, shown in this table for two or more applications, parallels rather closely that presented for the warm room in Table 1. As to numbers of applications, the results in Table 2 indicate merely that more than one was needed under the conditions and timing of this experiment.

Summary

Two exploratory-type experiments were conducted at Fort Collins, Colorado, during the period, November 1956 to May 1957, to study the possibility of hastening reproduction in a bolting-resistant sugar beet strain by means of gibberellic acid. Although relatively small numbers of plants were used, the results were so striking as to warrant the conclusion that, with at least one type of bolting-resistant sugar beet, gibberellic acid can serve as a substitute for a substantial part of the photothermal-induction treatment normally required for satisfactory reproductive development. In this way, the amount of time required to produce the complete life cycle can be reduced materially.

The NB1 sugar beet strain, used in this study, normally requires considerably more than 43 days' photothermal induction for satisfactory reproductive development of young seedlings, and well over six months' total time for the complete life cycle. In this study, 43 days' induction appeared to be adequate, where followed by four foliar applications of gibberellic acid (aqueous solution, 1,000 p.p.m.), and 11 of a set of 12 plants, so treated, produced mature seed of good viability within approximately 25 weeks from the date when the original seed was planted.

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Results of Seed Treatment Tests

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Chemical materials for seed treatment are being placed on the market in increasing numbers each year. Since seed treatment is a standard practice in most of the territories where sugar beets are grown, a need for information about these new materials has been created. This paper presents the results of three-years' testing of various fungicides in several locations of the American Crystal Sugar Company's operation. Results also are present on the effects of two fungicides applied at different rates on stored beet seeds and the effectiveness of these fungicides under field conditions after several months in storage.

Tests were designed in 1954 to include seven seed treatments and an untreated check in an 8 x 8 Latin square. The Company's standard procedure of Phygon treatment was used as a check and was also included as one of the seven treatments. The plot size was single rows ten feet long and the seed used was processed 7/64 to 9/64 inch segments with a laboratory germination of 90 percent. One seed per inch, or a total of 120 seeds per plot, was planted with a belt planter.

1954 Results

The 1954 tests were repeated at the following locations: Rocky Ford, Colorado; Mason City, Iowa; and the Red River Valley of Minnesota. Each of these locations had two tests, with a third test conducted at Mason City under root-rot conditions. The composite results of these tests are shown in Table 1 for individual and mean rankings of the eight treatments at the seven different locations.

The mean ranking in the above table shows Orthocide 75 ranked first in all seven tests as to the number of plants which survived. In nearly all tests it was significantly above the untreated check. Manzate rated second, Phygon third and Ceresan (NI) as fourth. However, in only one case was Manzate statistically better than Phygon and in two of the seven tests it was significantly better than New Improved Ceresan. In the majority of the tests, Orthocide 75 was not statistically better than the other top three treatments, however, it did obtain top ranking in all tests and this should not be overlooked.

With the promising performance of Orthocide 75 in the 1954 tests, it seemed advisable to obtain additional data in replicated tests with other chemical fungicides. The tests conducted in 1955 were very similar to those carried out the previous year, except that two different rates of Orthocide 75 (8 and 12 ounces) were included and the tests were conducted over a wider range of areas.

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[2] The authors of this paper wish to acknowledge Dr. A. R. Downie, for his part in outlining these tests and to Dr. R. E. Finkner, for much of the statistical analysis and interpretation of the results. Dr. Downie and Dr. Finkner are Assistant General Agriculturist and Research Station Manager respectively for the American Crystal Sugar Company.

Table 1.—Individual and Mean Ranking of the Eight Treatments at Seven Different Locations in 1954.

Treatment	Rate per 100 lbs. seed	LOCATIONS[1]							Mean
		1	2	3	4	5	6	7	
Orthocide 75	12 oz.	1	1	1	1	1	1	1	1.0
Manzate	8 oz.	2	4	2	3	3	2	2	2.6
Phygon	4 oz.	3	3	3	5	2	5	3	3.4
Ceresan (NI)	6 oz.	5	5	4	2	4	4	4	4.0
Arasan	2 oz.[2]	4	2	8	7	6	3	5	5.0
Ceresan (M)	6 oz.	6	6	7	4	5	8	6	6.0
Chemical 275 (PCNB)	8 oz.	7	7	5	6	7	7	8	6.7
Check	—	8	8	6	8	8	6	7	7.3

[2] Arasan was applied at 2 ounces per 100 pounds. although the recommended rate was 6 to 8 ounces.

[1] Location 1. Rocky Ford, Colorado
2. Rocky Ford, Colorado
3. Mason City, Iowa
4. Stewart, Minnesota
5. Mason City, Iowa (Root Rot Nursery)
6. East Grand Forks, Minnesota
7. Moorhead, Minnesota

1955 Results

In 1955, tests were designed to include six seed treatments and an untreated check in a 7 x 7 Latin square. The size of plot and method of planting were the same as used in 1954, with the exception of California where the plots were hand planted with seed spaced three inches apart and 100 seeds per plot were used.

The tests were conducted in five different areas; one each in California and Iowa, two each in Montana and Colorado, and three in Minnesota. The individual and mean rankings of the seven treatments at the nine locations are given in Table 2.

Table 2.—Individual and Mean Rankings of the Seven Treatments at the Nine Locations in 1955.

Treatment	Rate per 100 lbs. seed	LOCATIONS[1]									Mean
		1	2	3	4	5	6	7	8	9	
Orthocide 75	12 oz.	1	4	6	1	1	1	3	2	3	2.4
Orthocide 75	8 oz.	3	1	1	6	6	5	4	1	2	3.2
Phygon	4 oz.	2	5	3	4	2	2	2	3	6	3.2
Manzate	8 oz.	6	2	2	2	4	3	5	4	1	3.2
Ceresan (NI)	6 oz.	4	6	4	5	3	4	1	6	4	4.0
Arasan	8 oz.	5	3	5	3	5	6	6	5	5	4.8
Check	—	7	7	7	7	7	7	7	7	7	7

[1] Location 1. Clarksburg, California
2. Missoula, Montana
3. Missoula. Montana
4. Rocky Ford, Colorado
5. Rocky Ford, Colorado
6. Mason City, Iowa
7. Mankato, Minnesota
8. Moorhead Minnesota
9. East Grand Forks, Minnesota

Orthocide did not give the outstanding performance in 1955 that it did in 1954. However, Orthocide 75 at the 12-ounce rate did rank first. If the total number of seedlings counted in all locations is considered, Orthocide, at the 12-ounce rate, would rate first and the 8-ounce application would rate second.

The mean rankings show three different treatments to be equal for second, but in actually ranking by total number of seedlings, they are as shown in the table in the following order: Orthocide 75 at 8-ounces, Phygon, and Manzate.

Perhaps as a general trend, Orthocide at the 12-ounce rate gave better stands in the southern beet growing areas, while in northern locations, the 8-ounce rate gave better stands since the 12-ounce rate caused some damaging effects. This interaction of treatment and location was a consistant factor in the nine-location tests. The four tests conducted in the northern area, (Montana and the Red River Valley) produced better stand counts from the 8-ounce treatments, while the other five tests, in more southernly locations, showed better results from the 12-ounce treatment.

In the tests where seedling diseases were not present, there were no beneficial reactions from the use of Orthocide, but in the tests where significant differences were detected, it was found that one or the other Orthocide treatment ranked top.

Three of the individual tests are shown in Table 3 to bring out these points. In the California test the 12-ounce rate of Orthocide was higher than any other treatment; in the Montana tests the 8-ounce treatment ranked top. Both are tests showing significant differences. From a test conducted at Mankato, Minnesota, in the absence of damping-off organisms, it should be noted that non-significant effects resulted from treatment. Both rates of Orthocide gave mean results as shown in Table 3.

Table 3.—The Mean Germination of Three Tests in Three Different Locations Showing a Treatment-Location Interaction.

Treatment	Rate per 100 lbs. of seed	California Percent Field Germination	Montana Average Seedling Count	Mankato Average Seedling Count
Orthocide 75	12 oz.	66.6	79.6	103.4
Phygon	4 oz.	58.3	85.9	104.4
Orthocide 75	8 oz.	57.3	98.8	102.4
Ceresan (NI)	6 oz.	52.9	84.6	110.7
Arasan	8 oz.	46.4	81.6	93.6
Manzate	8 oz.	46.0	93.9	96.9
Check	—	42.1	73.6	92.3
General Mean		52.8	85.4	100.5
LSD (19:1)		6.0	6.7	NS
LSD (99:1)		8.0	9.0	NS
C. V.		10.6%	7.0%	13.7%

Conditions were nearly ideal for conducting the California test. There was a very good seed bed and good moisture at the time of planting. Seed balls were hand planted and spaced three inches apart. Counts were made of the percentage of seed balls having emergence, not on total seedlings.

All treatments, with the exception of Orthocide at the 12-ounce rate, were significantly better than the check in the Missoula test. The four top-ranking treatments produced results highly significant over the check. Visually there was no difference between various treatments for seedling vigor or indication of damage to seedlings. Apparently the 12-ounce rate of Orthocide caused a reduction in stand even though damage was not noticeable.

In the Mankato test there were no significant differences between any of the treatments at the five-percent level. No visable evidence of damping-off was noticed in this area.

From the data accumulated in the past two years from replicated plot tests, it would appear obvious that Orthocide 75 may have great possibilities as a seed protectant. There are, however, certain other characteristics which a good fungicide must have before it can be used on beet seed. For example, a fungicide must not lower the germination of the seeds even though it is stored in a warehouse for a year or more.

Storage Results

Therefore, an experiment was set up to determine whether or not Orthocide 75 had any effect on stored beet seeds. The experiment also was designed to test different rates of application, since a high dosage of a fungicide might decrease the germination to a greater degree than a low dosage. The writers also were interested in whether or not Phygon will decrease the germination when it is applied at heavy dosages, therefore it was included at the different rates as a check. An untreated check was included so that the comparison between treated and untreated samples could be calculated.

The five different dosages, 4, 6, 8, 10, and 12 ounces per 100 pounds of seed were chosen, since an additive increment (in this case 2 ounces) will allow for the testing of any possible trends such as linear, quadratic, etc.

The experiment was set up in a 5 x 5 + 1 factorial completely randomized design. Five samples of 100 seeds for each treatment were counted and germinated each month. The experiment was planned to stop after 20-months' data had been obtained. The analyses of these findings are reported in Table 4.

In general the check (no treatment) has kept a germination higher than either treatment, but not statisically different. The same was true of Orthocide over Phygon. Although significant differences were detected for the months of July and August in 1956 and January of 1957, these were hard to explain. It may be an interaction with temperatures, or to random chance variations.

Table 4.—Germination Data for Various Rates of Orthocide and Phygon for 20 Months.

Tretament	Application Rates	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	April
Orthocide 75	4 oz.	89.6	78.4	84.4	89.5	84.4	82.2	87.5	88.2	89.2	85.6	82.0	77.4	81.6	88.6	88.6	88.4	84.2	83.2	88.2
Orthocide 75	6 oz.	84.0	79.8	85.2	86.6	85.0	81.6	85.7	87.8	89.0	90.2	83.4	79.2	84.8	84.8	83.2	87.6	87.8	86.0	84.8
Orthocide 75	8 oz.	86.6	85.4	90.0	89.5	85.6	84.6	89.6	88.2	85.4	86.4	83.4	79.8	85.8	86.4	87.6	84.2	88.6	85.4	85.6
Orthocide 75	10 oz.	85.4	81.8	88.6	90.0	84.0	84.6	90.0	88.4	84.6	89.0	86.8	81.8	85.2	85.6	87.0	89.0	87.8	86.0	88 0
Orthocide 75	12 oz.	85.4	81.4	83.4	90.8	87.6	80.2	86.2	89.4	87.6	87.6	86.6	83.4	81.6	87.2	86.4	83.4	81.4	84.2	88.4
Check	—	88.0	85.0	87.6	90.6	89.0	84.6	89.8	88.4	89.6	87.2	88.0	82.6	86.0	87.2	86.3	85.6	88.8	85.8	85.2
Phygon	4 oz.	86.4	84.4	86.8	87.2	84.6	83.6	87.6	84.6	84.6	87.4	85.8	80.0	81.4	82.0	86.6	85.6	85.4	81.6	87.8
Phygon	6 oz.	86.6	82.0	84.0	88.4	87.2	83.2	86.4	87.0	87.2	86.0	82.2	79.4	80.6	86.2	85.8	82.8	82.0	85.0	84.0
Phygon	8 oz.	85.4	84.8	88.2	83.6	85.0	78.0	87.6	83.4	87.8	87.8	76.6	70.4	83.4	84.6	83.6	85.4	81.4	87.2	87.0
Phygon	10 oz.	85.6	79.8	85.4	89.8	86.4	32.6	84.0	87.6	86.4	86.6	81.0	77.2	85.2	83.4	83.0	85.8	84.2	86.0	84.2
Phygon	12 oz.	86.2	85.2	86.4	86.4	88.0	82.0	85.6	86.2	87.0	82.8	84.4	80.4	80.4	85.2	83.6	85.8	85.2	85.8	87.2
General Mean		86.3	82.5	86.4	88.4	86.1	82.5	87.3	87.2	87.1	87.0	83.9	79.2	83.3	85.6	85.7	85.8	85.2	84.9	86.4
F. Values		0.5	1.85	1.60	1.30	0.86	0.76	1.0	0.92	0.86	1.42	2.62*	3.12**	1.18	1.2	1.39	1.41	3.63**	1.13	1.56

(F = 2.06 at the 5% point of significance)
(F = 2.75 at the 1% point of significance)

Means for 19 Readings	
85.33	85.70 (Orthocide)
85.08	
86.22	
86.51	
85.38	
87.15	87.15 (Check)
84.92	84.49 (Phygon)
84.53	
83.75	
84.43	
84.84	

The mean of the two treatments and check for all months and rates are shown in Table 4. There were no statistical differences between any of these treatments and all gave satisfactory germinations at the end of 20 months.

From the data in Table 4, it was obvious that fungicidal treatments used in these tests were not detected as being detrimental to germination of beet seed even after 20 months in storage. The question then was to determine whether or not these fungicides would still be effective after 20 months in storage, in controlling damping-off organisms.

1956 Results

To determine their effectiveness after 20 months in storage, samples of each of the seed lots which were in the storage test were planted in the field in replicated tests. The plots which were single rows ten feet long and one seed per inch, or a total of 120 seeds, were planted by a belt planter. The eleven different treatments were replicated five times in a 11 x 5 randomized block design and these tests were repeated at three locations; Rocky Ford, Colorado; Mason City, Iowa; and East Grand Forks, Minnesota. The results of these tests are shown in Table 5 as individual and mean rankings of the eleven treatments at the three locations.

Table 5.—Individual and Mean Ranking of Eleven Treatments at Three Different Locations.

Treatment	Rate per 100 lbs. seed	LOCATIONS[1] 1	2	3	Mean	Ranking
Orthocide 75	4 oz.	2	9	4	5.0	(5)
Orthocide 75	6 oz.	3	2	8	4.3	(4)
Orthocide 75	8 oz.	1	5	5	3.7	(2)
Orthocide 75	10 oz.	4	3	2	3.0	(1)
Orthocide 75	12 oz.	9	1	1	3.7	(2)
Check	—	10	11	11	10.7	(11)
Phygon	4 oz.	8	10	3	7.0	(7)
Phygon	6 oz.	7	7	9	7.7	(9)
Phygon	8 oz.	5	4	7	5.3	(6)
Phygon	10 oz.	6	6	10	7.3	(8)
Phygon	12 oz.	11	8	6	8.3	(10)

[1] Location 1. Rocky Ford, Colorado
2. Mason City, Iowa
3. East Grand Forks, Minnesota

No significant differences were detected among the various treatments at Mason City, Iowa, or East Grand Forks, Minnesota. However, at Rocky Ford significant differences were detected as shown in Table 6.

In Table 6 significant differences between treated seed and non-treated seed existed. This is to be expected if damping-off organisms were present. There also was a significant difference between the two fungicides in favor of Orthocide 75 even after 20 months of storage.

Even though significance was reached only in one of the three tests, we can conclude that Orthocide 75 has no adverse effects on beet seed even after 20 months of storage. This was the primary question which the test was designed to answer.

Table 6.—Analysis of Variance for Seed Treatment Test at Rocky Ford, Colorado, 1956.

Source of Variation	D/F	Sums Squares	Mean Squares	F Value
Blocks	4	1343.0	335.8	
Treatments	10	3041.0	304.1	2.44*
Check vs. Treated	1	635.2	635.2	5.10*
Between Fungicides	1	976.8	976.8	7.83**
Between Rates	4	1365.1	341.3	2.73*
Fungicides x Rates	4	63.9	16.0	0.13
Error	40	4991.0	124.8	
Total	54	9375.0		

The trend of the results as shown in Table 5 also showed Orthocide 75 to be more effective after this storage period than Phygon, and Phygon was better than no treatment.

The data also show that seed treated with Orthocide 75 at rates from 8 to 12 ounces to be equally effective.

Summary

Two years of replicated field results were reported using various chemicals for seed treatments. Orthocide treatment was outstanding in both years. In 1954 it was superior to all other treatments, however, in 1955 it appeared to have an interaction with location.

Orthocide and Phygon at various rates did not decrease the germination of the seed after 20 months of storage.

Orthocide treated seed still remained superior in field tests even after being stored for 20 months.

Economy in Filter Area for Standard Liquor Filtration

MARTELL B. HARRIS[1]

For many years the plate and frame filter has been practically the only type of filter used for standard liquor filtration in the beet sugar plant. In recent years, there have been several types of filters introduced for this purpose. Each has certain advantages and possibly some disadvantages. It appears that some of the basic concepts previously generally accepted, should be scrutinized in the light of the new equipment available. In other words, previously accepted rules may not apply to the more recent types of filters.

The action of diatomite in aiding filtration is well established and has been discussed in many articles. In spite of this, one of the first considerations concerning replacement equipment is rate of filtration.

A filter's function is that of furnishing a supporting medium for the deposit of a mixture of diatomite, slimes and other insoluble impurities in the liquor as the liquor passes through. The cake thus formed is the factor regulating the rate at which the liquid can be filtered.

Any equipment that furnishes such a medium, properly supported to provide free flow of the liquor after it passes through the cake, should have the same filtering capacity per square foot of filtering area.

Offhand, one might deduce that regardless of type of filter, equal total area is required. However, economic considerations indicate this is not true.

In the May 1941 issue of "Sugar," Robert D. Kent, then of The Dicalite Company, discussed the optimum filteraid for standard liquor. He stated the correct amount of filteraid is that which will just about but not quite fill the cake space in a press as the maximum pressure is reached at the end of the cycle The optimum amount of filteraid can be established for a given standard liquor by experimental means. A quick method of determining this and adjusting the filteraid feed accordingly might result in considerable saving and would justify some work. For discussion here the optimum filteraid is assumed.

Brix, carbonation and other conditions under plant control, affect filtration considerably. The optimum conditions as far as these are concerned are quite well known by the operators, chemists, and engineers.

The data used for plotting the rate curves, etc., was obtained by actual bomb filter tests on standard liquor in a mill under average conditions. In this case, it was 66 brix at a temperature of 90° C.

Figure 1 is a log log plot of accumulated volume vs. time at 10 lbs. per sq. in. constant pressure. The basic formula for volume vs. time at constant pressure is $V = K\Theta^n$. Volume being a function of time at an exponent power, a straight line is obtained. This is true when sufficient filteraid is used to prevent compression of cake.

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[1] Filtration Engineer Dicalite Division, Great Lakes Carbon Corporation, Los Angeles 17, California.

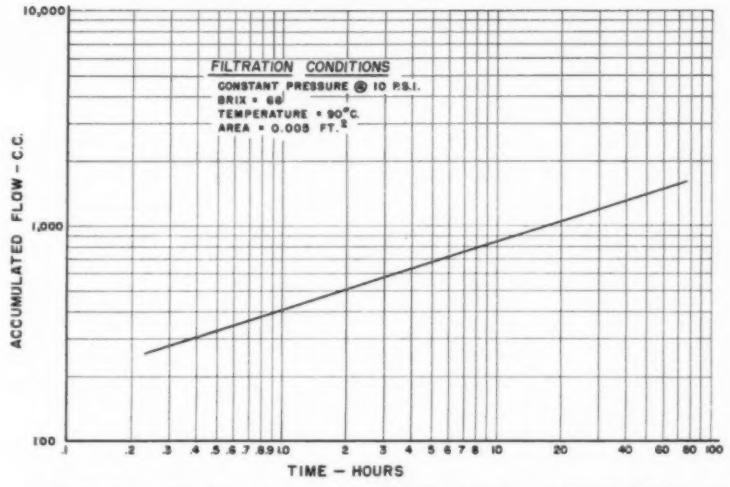
10,000
1,000
100
FILTRATION CONDITIONS
CONSTANT PRESSURE @ 10 P.S.I.
BRIX = 60
TEMPERATURE = 90°C.
AREA = 0.005 FT.²
ACCUMULATED FLOW - C.C.
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 2 3 4 5 6 7 8 10 20 40 60 80 100
TIME — HOURS

Figure 1.—A log log plot of accumulated volume vs. time at 10 lbs. per sq. in. constant pressure.

This plot can be used for predicting plant flow on a given plant liquor and filteraid dosage. For example, if the average flow per square foot of filtering area is desired for a 10-hour cycle, the line at 600 minutes will show that the total flow for the filter disc used is 850 cc. To convert the cc per .005 sq. ft. (which was the area of the disc) to gallons per sq. ft., multiply by the factor .0528. This will give 44.9 total gallons filtered per sq. ft. or an average of 4.49 gal. per sq. ft./hr. at 10 lbs. constant pressure. To convert this to a constant flow at the plant maximum presure of 50 lbs. per sq. in., multiply one over the square root of two times the square root of the different pressures, or $4.49 \times \frac{1}{\sqrt{2}} \sqrt{\frac{50}{50}} = 7.09$. This means with sufficient filteraid, if the filters were set to run 7.09 gallons per sq. ft./hr., the maximum pressure of 50 lbs. per sq. in. would be obtained in 10 hours. This was the method used to calculate the data used for Figure 3.

For the sake of pointing out the tremendous drop in flow rate with time (conversely this could be the equivalent increase in pressure with time at constant flow), instantaneous rates vs. time were plotted. To do this we differentiated the formula $V = K\Theta^n$ was with respect to time to get $\frac{dV}{d\Theta} = Kn\Theta^{(n-1)}$. Then, of course, values for Θ were assumed and the equivalent rates were calculated as shown in Figure 2.

If a filter could be operated on very short cycles, the total filter area required would thus be very small. The shortest time duration of a cycle that can be tolerated is dependent on the cleaning time and other economic considerations. Clarity considerations might also eliminate extremely short cycles.

Table 1.—Data Used for Plotting Curves on Figure 3

Opr. Time	Vol. cc.	Down Time	Total Time	Gal/sq. ft. per hr.	Down Time	Total Time	Gal/sq. ft. per hr.
¼	265	¼	½	44.2	½	¾	29.5
½	330	¼	¾	36.7	½	1.0	27.6
¾	375	¼	1.0	31.3	½	1.25	25.0
1	410	¼	1.25	27.4	½	1.5	22.8
1.5	460	¼	1.75	21.9	½	2.0	19.2
2	510	¼	2.25	18.9	½	2.5	17.0
3	580	¼	3.25	14.9	½	3.5	13.8
5	680	¼	5.25	10.8	½	5.5	10.3
10	850	¼	10.25	6.9	½	10.5	6.8
20	1050	¼	20.25	4.3	½	20.5	4.3
30	1200	¼	30.35	3.3	½	30.5	3.3
40	1320	¼	40.25	2.7	½	40.5	2.7
48	1400	¼	48.25	2.4	½	48.5	2.4
Opr. Time	**Vol. cc.**						
¼	265	¾	1.0	22.1	1	1.25	17.7
½	330	¾	1.25	22.0	1	1.5	18.4
¾	375	¾	1.5	20.9	1	1.75	17.9
1	410	¾	1.75	19.6	1	2.0	17.1
1.5	460	¾	2.25	17.1	1	2.5	15.4
2	510	¾	2.75	15.5	1	3.0	14.2
3	580	¾	3.75	12.9	1	4.0	12.1
5	680	¾	5.75	9.9	1	6.0	9.5
10	850	¾	10.75	6.6	1	11.0	6.5
20	1050	¾	20.75	4.2	1	21.0	4.2
30	1200	¾	30.75	3.3	1	31.0	3.2
40	1320	¾	40.75	2.7	1	41.0	2.7
48	1400	¾	48.75	2.4	1	49.0	2.4
Opr. Time	**Vol. cc.**						
¼	265	1.5	1.75	12.6	2	2.25	9.8
½	330	1.5	2.0	13.8	2	2.5	11.0
¾	375	1.5	2.25	13.9	2	2.75	11.4
1	410	1.5	2.5	13.7	2	3.0	11.4
1.5	460	1.5	3.0	12.8	2	3.5	11.0
2	510	1.5	3.5	12.2	2	4.0	10.6
3	580	1.5	4.5	10.8	2	5.0	9.7
5	680	1.5	6.5	8.7	2	7.0	8.1
10	850	1.5	11.5	6.2	2	12.0	5.9
20	1050	1.5	21.5	4.1	2	22.0	4.0
30	1200	1.5	31.5	3.2	2	32.0	3.1
40	1320	1.5	41.5	2.7	2	42.0	2.6
48	1400	1.5	49.5	2.4	2	50.0	2.3

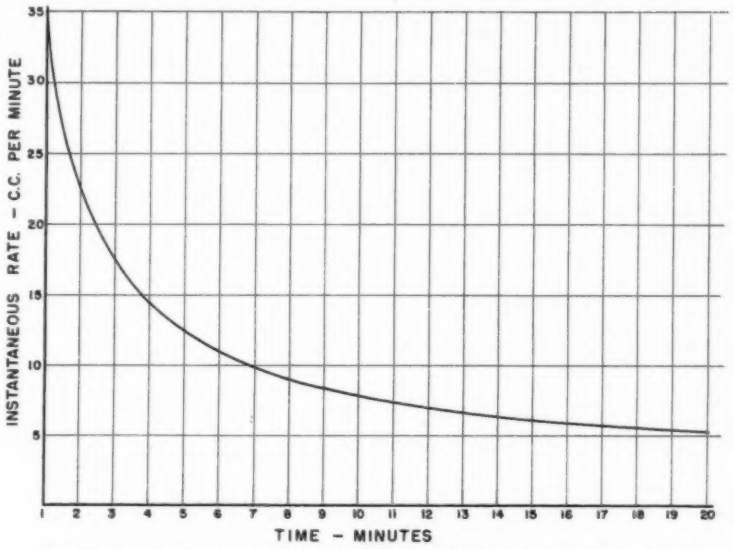

Figure 2.—Equivalent rates calculated with assumed values of Θ.

Figure 1 was used to develop the data for Figure 3 and was calculated as per the example cited. Figure 3 shows plots of gallons filtered per sq. ft./hr. at 50 lbs. maximum pressure using constant flow versus the length of cycle. In this case, however, the length of cycle refers to the operating cycle plus the down-time. For example, the rate of flow is the total gallonage filtered during the operating time divided by the operating time plus the down-time. Table 1 shows the data used in plotting the curves on Figure 3. It will be noticed the curves converge. This is due to the fact that on the longer cycles the loss of flow because of down-time becomes quite small in relation to the total flow. These curves were plotted on semi-log paper merely for convenience.

It was previously pointed out by use of the curve on Figure 2, that very high rates of filtration can be obtained on short cycles. Figure 3 also shows this. Actually, it can be shown mathematically that if enough filteraid is used to get a theoretically perfect cycle, the maximum output of a filter is obtained when the operating time is equal to the down-time.

When considering economy, labor costs for cleaning, and filter cloth costs are more favorable with long cycles since more total liquor is filtered per each cleaning and dressing. On the other hand, depreciation cost would be lowest if the maximum output per filter or short cycles were maintained. It was felt it might be interesting to try to find the balance where lowest total cost is obtained.

In the following, it is not intended to compare the economy of one type filter vs. another. This would result in erroneous conclusions. If a given type appears to be the most economical, it is possible this type might

require double filtration to insure necessary safety and thus result in an over-all cost quite comparable to another type which appears higher in operational cost but on which single filtration is considered sufficient. Certain sugar beet areas may have a history of producing easier filtering juices than other areas. This could affect the relative costs. Maintenance costs might affect the choice. Some plants might afford more room for a filter station than others, thus favoring a certain type. Finally, the yearly operating time of a mill would affect the choice of filters considerably, since a high capital investment might be hard to justify in a mill running short campaigns.

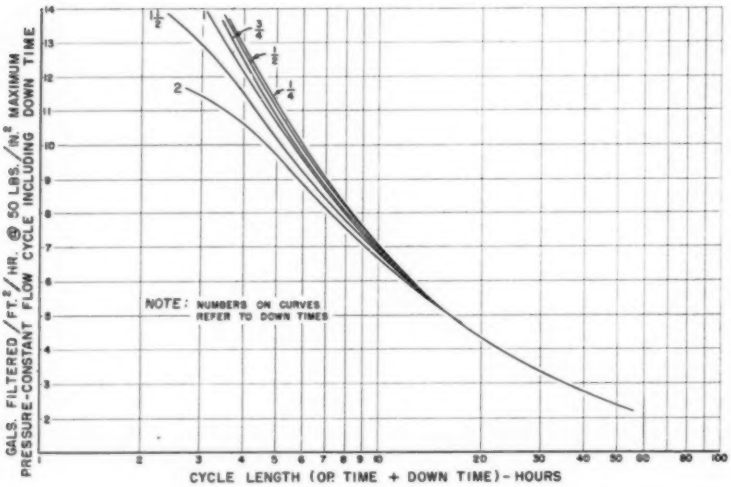
GALS. FILTERED / FT.² / HR. @ 50 LBS. / IN.² MAXIMUM PRESSURE-CONSTANT FLOW CYCLE INCLUDING DOWN TIME
CYCLE LENGTH (OP. TIME + DOWN TIME) - HOURS
NOTE: NUMBERS ON CURVES REFER TO DOWN TIMES
1½
1
¾
½
¼
2

Figure 3.—Plots of gallons of filtered per sq. ft./hr. at 50 lbs. maximum pressure using constant flow vs. the length of cycle.

The tables that follow are merely examples of how an engineer, after selecting a filter that will do the best job for his particular plant, might determine the most economical filter area and the most economical operation of the filter he selects.

Table 2 refers to a type of filter that can be cleaned and put back on the line in 15 minutes. The type of filter that might permit this would be an internal sluicing filter. The most economical area based on the assumed costs appears to be at 1200 square feet or two 600 sq. ft. filters for the assumed plant flow of 12,000 gallons per hour. Table 3 is based on the same type with an assumed cleaning time of one-half hour and indicates best economy between 1200 and 1800 sq. ft. total area.

It might be of interest to explain how the costs in the table were calculated. The required over-all rate per sq. ft. for the given plant flow

Table 2.—Internal sluicing type filter, ¼ hr. cleaning time, for 12,000 gal. standard liquor per hour, labor cost at $1.75 per man hour, approximate precoat cost at $43.00 per 100 lbs. asbestos fibre precoating material using 10 lbs. per precoat per filter, approximate cost of filter at $15,000.00 for the 600 sq. ft. size.

No. of filters	1	2	3	4
Rate gal. per sq. ft. per hr.	20	10	6.67	5.0
Cycle length hrs.	2.1	5.9	10.7	16.3
Volume per cycle per filter	25,200	35,400	42,816	48,900
Labor cost cents per gal.	.00174	.00124	.00102	.00089
Replacement cost cents per gal.	.00278	.00556	.00833	.01111
Precoat cost cents per gal.	.01731	.01215	.01004	.00879
Total cost cents per gal.	.02183	.01895	.01939	.02079

Table 3.—Internal sluicing type filter, ½ hr. cleaning time, for 12,000 gal. standard liquor per hour, labor cost at $1.75 per man hour, approximate precoat cost at $43.00 per 100 lbs. asbestos fibre precoating material using 10 lbs. per precoat per filter, approximate cost of filter at $15,000.00 for the 600 sq. ft. size.

No. of filters	1	2	3	4
Rate gal. per sq. ft. per hr.	20	10	6.67	5.0
Cycle length hrs.	1.9	5.8	10.6	16.3
Volume per cycle per filter	22,800	34,800	42,420	48,900
Labor cost cents per gal.	.00384	.00251	.00206	.00179
Replacement cost cents per gal.	.00278	.00556	.00833	.01111
Precoat cost cents per gal.	.01886	.01235	.01014	.00879
Total cost cents per gal.	.02548	.02042	.02053	.02169

was first determined for an assumed number of filters. The required total cycle was then obtained from Figure 3. The volume per cycle can then be calculated. The labor and cloth costs per gallon are then obtained. The replacement or depreciation costs are based on the number of filters assumed handling the given plant flow 100 days per year for 20 years

Table 4 is for the hand-sluicing types that might be cleaned in one-half hour and indicates four filters of 600 sq. ft. each or a total of 2400 sq. ft. as the cheapest. Table 5 is the same as 4 assuming ¾ hour per cleaning.

Table 4.—Hand sluicing type filter, ½ hr. cleaning time for 12,000 gal. standard liquor per hr. labor cost at $1.75 per man hour, approximate cloth cost using Nylon at $5.40 per yard (used 40 cycles), approximate cost of filter $14,000 for the 600 sq. ft. size.

No. of filters	2	3	4	6
Rate gal. per sq. ft. per hr.	10	6.67	5.0	3.33
Cycle length hrs.	5.8	10.6	16.3	29.7
Volume per cycle per filter	34,800	42,420	48,900	59,340
Labor cost cents per gal.	.00251	.00206	.00179	.00147
Replacement cost cents per gal.	.00486	.00729	.00972	.01458
Cloth cost cents per gal.	.02586	.02122	.01840	.01517
Total cost cents per gal.	.03323	.03057	.02991	.03122

Table 5.—Hand sluicing type filter, ¾ hr. cleaning time for 12,000 gal. standard liquor per hr. Labor cost at $1.75 per man hour, approximate cloth cost using Nylon at $5.40 per yard (used 40 cycles), approximate cost of filter $14,000 for the 600 sq. ft. size.

No. of filters	2	3	4	6
Rate gal. per sq. ft. per hr.	10	6.67	5.0	3.33
Cycle length hrs.	5.6	10.4	16.3	29.7
Volume per cycle per filter	33,600	41,620	48,900	59,340
Labor cost cents per gal.	.00390	.00315	.00268	.00221
Replacement cost cents per gal.	.00486	.00729	.00972	.01458
Cloth cost cents per gal.	.02679	.02162	.01840	.01517
Total cost cents per gal.	.03555	.03206	.03080	.03196

Tables 6 and 7 are based on a horizontal leaf type filter and indicate fifteen 142 sq. ft. filters if they can be cleaned in ¾ hour or 1 hour.

Table 6.—Horizontal leaf type filter, ¾ hr. cleaning time, for 12,000 gal. standard liquor per hr., labor cost at $1.75 per man hour, approximate cloth cost using Nylon at $5.40 per yard (used 40 cycles), approximate cost of filter $6,000 for the 142.3 sq. ft. size.

No. of filters	10	15	20	25
Rate gal. per sq. ft. per hr.	8.43	5.62	4.22	3.37
Cycle length hrs.	7.4	13.6	21.0	29.0
Volume per cycle per filter	8,877	10,876	12,611	13,907
Labor cost cents per gal.	.01476	.01204	.01039	.00942
Replacement cost cents per gal.	.01042	.01562	.02083	.02604
Cloth cost cents per gal.	.02405	.01963	.01693	.01535
Total cost cents per gal.	.04923	.04729	.04815	.05081

Table 7.—Horizontal leaf type filter, 1 hr. cleaning time, for 12,000 gal. standard liquor per hr., labor cost at $1.75 per man hour, approximate cloth cost using Nylon at $5.40 per yard (used 40 cycles), approximate cost of filter $6,000 for the 142.3 sq. ft. size.

No. of filters	10	15	20	25
Rate gal. per sq. ft. per hr.	8.43	5.62	4.22	3.37
Cycle length hrs.	7.2	13.6	21.0	29.0
Volume per cycle per filter	8,637	10,876	12,611	13,907
Labor cost cents per gal.	.02026	.01609	.01388	.01258
Replacement cost cents per gal.	.01042	.01562	.02083	.02604
Cloth cost cents per gal.	.02471	.01963	.01693	.01535
Total cost cents per gal.	.05539	.05134	.05164	.05397

Tables 8 and 9 consider the plate and frame. Both seem to indicate around 6,000 sq. ft. for best economy.

In traveling among and talking with operating personnel, the general feeling with regard to plate and frame filters is the longer the cycle, the better the operating efficiency. With an established filter station as is the case with the majority of the mills, this is probably true.

Table 8.—Plate and frame type filter, 1½ hr. cleaning time (2 men) for 12,000 gal. standard liquor per hr., labor cost at $1.75 per man hour, approximate cloth cost using cotton (used ave. 6.5 times) at $1.00 per sq. yd., approximate cost of 600 sq. ft. filter is $4,200.00.

No. of filters	6	8	10	12
Rate gal. per sq. ft. per hr.	3.33	2.5	2.0	1.67
Cycle length hrs.	29.7	45.0	61.0	74.0
Volume per cycle per filter	59,340	67,500	73,200	74,150
Labor cost cents per gal.	.00885	.00778	.00717	.00708
Replacement cost cents per gal.	.00438	.00583	.00729	.00875
Cloth cost cents per gal.	.01710	.01504	.01387	.01369
Total cost cents per gal.	.03033	.02866	.02833	.02952

Table 9.—Plate and frame type filter, 2-hr. cleaning time (2 men) for 12,000 gal. standard liquor per hr., labor cost at $1.75 per man hour, approximate cloth cost using cotton (used ave. 6.5 times) at $1.00 per sq. yd. approximate cost of 600 sq, ft. filter is $4,200.00.

No. of filters	6	8	10	12
Rate gal. per sq. ft. per hr.	3.33	2.5	2.0	1.67
Cycle length hrs.	29.7	45.0	61.0	74.0
Volume per cycle per filter	59,340	67,500	73,200	74,150
Labor cost cents per gal.	.01180	.01037	.00956	.00944
Replacement cost cents per gal.	.00438	.00583	.00729	.00875
Cloth cost cents per gal.	.01710	.01504	.01387	.01369
Total cost cents per gal.	.03328	.03124	.03072	.03188

Speaking of the optimum cycle length in Table 9, a 61-hour cycle is quite a long one. The possibility of the plate and frame filter having a cake space to accommodate such a cycle and whether the liquid velocities within the frame are sufficient to suspend filteraid was of concern. On the basis of .7 lbs. filteraid per ton of beets, a press with one and one-half inch frames should accommodate a 60-hour cycle In addition, the calculated velocity seems to be sufficient to suspend the filteraid.

Wire Mesh Entrainment Separators

J. E. Cooley[1]

Introduction

The liquid entrainment problem experienced within the beet sugar industry today is familiar to most of us. We have all realized the detrimental effects of sugar carryover in multieffect evaporators, concentrators, and vacuum pan operation.

During the evolution of these different phases of operation, many methods have been used in attempting to eliminate or control the problem of liquid entrainment. Some of the methods employed in attempting to control liquid entrainment are: (1) Baffles, either wooden or metal, (2) vanes, (3) catchalls, and (4) wire mesh entrainment separators. The first three methods are common and at times leave much to be desired. This paper is primarily concerned with the fourth method, wire mesh entrainment separators, which is one of the newer advances within the sugar industry for handling this problem.

First of all, it should be understood what detrimental effects are felt when entrainment is experienced. Probably the most glaring effect is the direct loss of sugar from production. This loss is cumulative from multieffect evaporator condensate systems and condenser water systems. This means the actual loss of sugar in terms of bags of sugar that cannot be recovered. In condenser water systems there are two ways in which losses may occur: (1) Sugar laden surplus condenser water goes to a sewer, and (2) sugar laden battery supply water that is taken from condenser water and causes higher sugar losses in beet pulp.

The second detrimental effect of sugar entrainment is the introduction of sugar contaminated condensate into boiler feed water. Sugar contaminated boiler feed water can result in:

1. Premature boiler tube failures and loss of productivity.
2. Reduction in beet slice from reduced boiler operating rates or failures.
3. High annual boiler cleaning costs from boiler tube fouling.
4. High chemical treatment costs to maintain the proper alkalinity of boiler feed water.

Finally, there will be the extra cost of defoaming agents that are used to combat foaming in evaporators.

Several years ago, the entrainment problem became critical within the petroleum industry. Resulting from experimental work, one of the best answers to the petroleum industry's entrainment problem was the wire mesh entrainment separator. Just recently, this type of entrainment separator was introduced to the sugar industry for use in the multieffect evaporators. The wire mesh entrainment separator is constructed of many layers the service for which the separator is to be used. This multilayer wire mesh is then mounted on a single grid and held in place by tie-down wires

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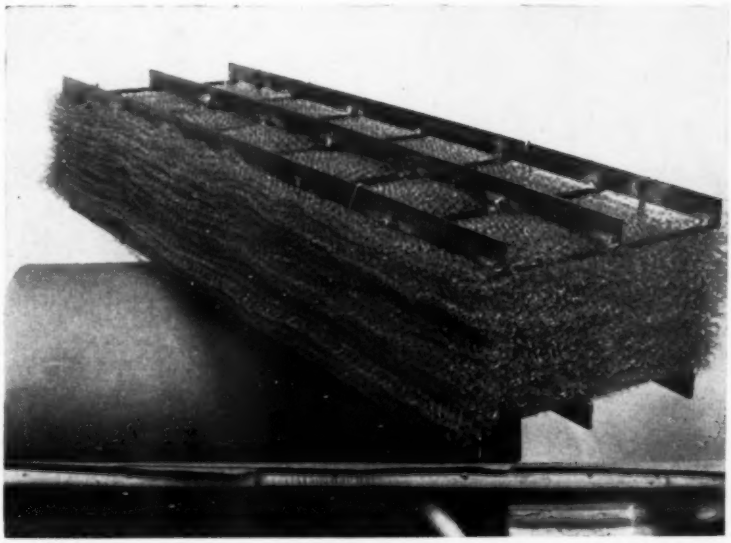

Figure 1.—Typical section of wire mesh entrainment separator of the double-grid design.

or, as an alternate, multilayer wire mesh is mounted between two grids which are welded together with spacer rods to maintain a constant-width type of sandwich unit. Figure 1 is an example of a typical wire mesh separator section of sandwich grid design. This particular section is approximately three feet long, and one foot wide, with the wire mesh being six inches thick. The wire mesh is quite porous offering little resistance to vapor flow. Light can be seen easily through the mesh. The materials of construction used in the manufacture of wire mesh entrainment separators naturally vary depending upon the service. This particular section is made completely of monel for use in juice evaporators where varying concentrations of hydrochloric acid are used for cleaning.

Figure 2, shows a typical wire mesh separator installation in a horizontal tube evaporator body. One section has been removed to show how the individual sections are installed. The ends of the strap which make up the bottom grid are held in place with monel tie-down wires. In the installation of this separator, as much head room as possible should be provided between liquid level and bottom of the wire mesh entrainment separator to reduce the possibility of foam actually reaching the separator.

The Spreckels Sugar Company has had a wire mesh entrainment separator of the single or bottom, grid design in operation for approximately 240 days and a wire mesh separator of the double or sandwich grid design for 100 days. After the first 100 days' operation with the single grid separator

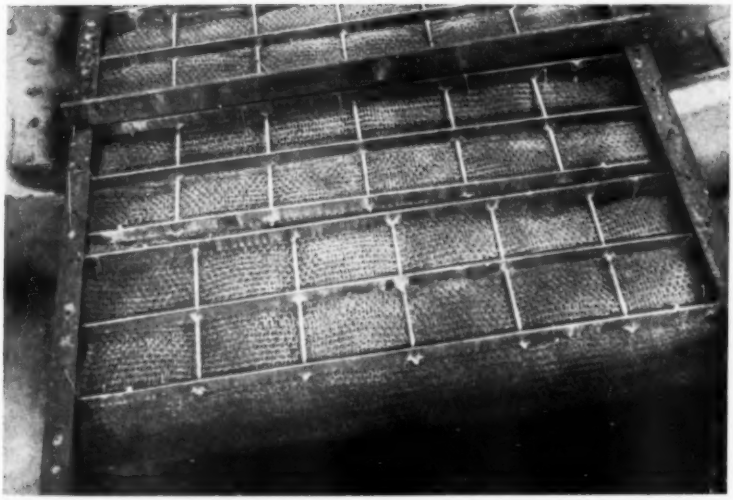

Figure 2.—Horizontal tube evaporator showing the method of installation of wire mesh entrainment separator sections within the body.

some loosening of the wire mesh away from the grid was noticed, while after 100 days' operation with the double grid separator, its condition had not changed. It is concluded, therefore, that the double grid wire mesh entrainment separator will have a longer life and require less maintenance than the single grid design.

Physical inspection revealed that no solid deposits appeared on or within either type of grid design. The results of these findings relieve concern about the possibility of gradual buildup of deposits.

When determining the cross-sectional area requirements for each body of the evaporator, an established formula is used which combines the liquid density and the vapor density to determine the allowable velocity and thus the required area. Arbitrarily, with the sanction of the manufacturer, a figure of 125 percent of the minimum required area was used. This was done to reduce the possibility of excessive pressure drop across a wire mesh separator and the possibility of excessive vapor velocity through a wire mesh separator because of liquid holdup within the wire mesh. The converse is also true in the application of this mesh to a particular piece of equipment in that excessively low velocities reduce entrainment efficiency.

Detailed tests were conducted on a horizontal tube evaportator body with a wire mesh entrainment separator on which data were collected hourly, for an eighteen-day period. The amount of sugar in condensate, temperature, and pressure of the body, and pressure drop across the wire

mesh separator were recorded. Similar data were collected at the same time on another identical evaporator body having no wire mesh entrainment separator. The parallel unit was operated under as near the same operating conditions as possible with respect to temperature, pressure, and evaporation load. The results of this test show that the wire mesh entrainment separator reduced sugar entrainment by 85 percent and that the pressure drop across the separator was approximately 0.3 inch of water. These data represent average figures. It was interesting to note that the amount of entrainment varied considerably on the unit without the wire mesh entrainment separator, while the amount of entrainment in the unit with the wire mesh was low and relatively uniform. Similarly, when the unit without the separator had very high surges of entrainment the unit with the wire mesh separator remained relatively free of entrainment. Since the wire mesh entrainment separator has the ability to stop sudden surges of entrainment, condensates for boiler feed water can now be had that are more stable with respect to sugar contamination. It is the sudden surges of large quantities of sugar that cause the most detrimental effect in boiler operation since the contaminated boiler feed water may get into the boiler before it can be detected.

Wire mesh entrainment separators with a 6-inch thickness, used in horizontal tube evaporators or vacuum pans, will cost approximately $30 per square foot and approximately $25 per square foot in vertical tube or circular pieces of equipment. These figures include both material and labor costs. Thus, an installation will have an average cost of $2000 per 1000 tons of beets sliced per day.

A means is available whereby proper entrainment separation can be obtained. However, before consideration is given to converting to this newer method of separation, consideration must be given to the potential savings that will result from improved entrainment removal. The following are the annual potential savings that can be anticipated, based on a typical horizontal tube evaporator installation, where all figures have been reduced to a common factor, the amount of savings per square foot of wire mesh entrainment separator. Figure 3 graphically illustrates the cost and potential savings for this particular installation.

1. Sugar losses in boiler feed water with 85 percent entrainment removal or $1.19/sq. ft. of wire mesh separator area.
2. Chemical costs to neutralize boiler feed water acidity or $0.08/sq. ft.
3. Annual boiler acid cleaning costs, currently required to remove scale primarily composed of precipitates from evaporator condensate or $2.10/sq. ft.
4. Cost of delays to factory operation due to sugar in boilers causing reduced boiler loads or $2.10/sq. ft.
5. Cost of evaporator defoaming agents can be reduced by 50 percent to 75 percent or $3.76/sq. ft.

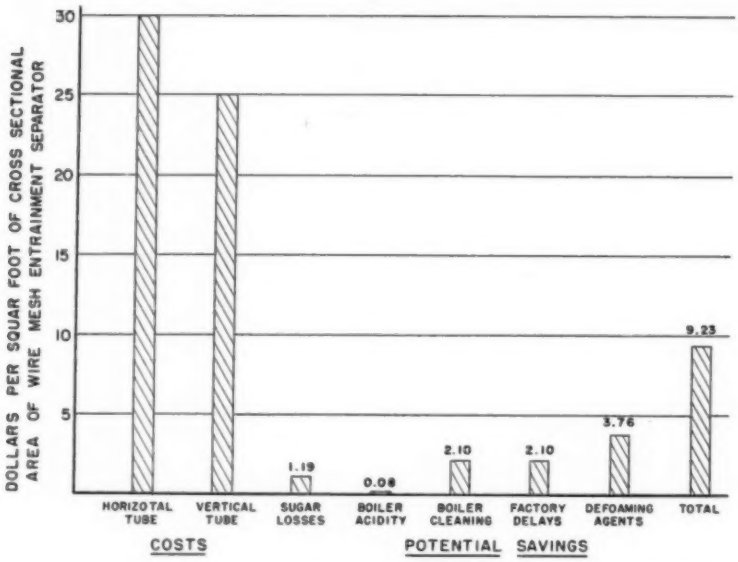

Figure 3.—Costs and potential savings per unit area of wire mesh entrainment separator.

The total annual potential savings, then, amount to $9.23/sq. ft. The anticipated life of wire mesh entrainment separators is from 10 to 15 years. By comparing the cost, life, and potential savings involved in installing wire mesh entrainment separators, a $9.23/sq. ft. annual savings for $25 to $30 investment is noted and the economic soundness of converting to this newer type of entrainment separator is clearly realized.

In addition to the potential savings just mentioned, there are irreducible savings that nevertheless make the installation of wire mesh separators more attractive. These are:

1. Reduced danger of internal damage to a boiler because of excessive sugar in boiler feed water.
2. Anticipation of an increase in boiler capacity in those instances where boilers have been operating under reduced capacities due to contaminated boiler feed water.
3. Longer life of vapor and condensate lines because of the absence of most of the corrosive substances, as with acid during boilouts.
4. Longer life of condensate pumps for the same reason as noted in 3 above.

Cost and potential savings that have been discussed reflect an optimistic outlook for the particular case cited. Each separate installation has its own application so that the potential savings may vary.

There has not been an opportunity to observe the use of the wire mesh entrainment separators within vacuum pans, but it is felt that the results obtained warrant serious consideration for this application.

Summary

In summary, the following points have been presented:

1. That a new method for controlling liquid entrainment has been introduced which is the wire mesh entrainment separator. The advantages of a double grid design over the single grid design have been noted.
2. That better boiler operation will result with a definite reduction in the danger of boiler damage because of a better quality boiler feed water.
3. That a monetary savings can be realized which will justify conversion of many pieces of equipment to this method of entrainment removal.

Notes Section

The *Journal of the American Society of Sugar Beet Technologists* is initiating with this issue, a "Notes Section." Contributions to this section should be short, informative, and of technical nature. This is the place to report on items too short for a paper, but of value to beet sugar and sugar beet research. Your contributions are invited.

Plastic Sheeting Useful in Storing Mother Beets and Stecklings. A combination of low temperature (about 40° F.) and high humidity (near 100 percent) provides near ideal conditions for storage of mother beets and stecklings. In the set up at The Great Western Experiment Station such roots have for several years been stored in jumbo cantaloupe crates, stacked five or six high in a root cellar. It has been relatively easy to obtain favorable temperatures, using artificial refrigeration units. Since this geographic area is characterized by low atmospheric humidity, the maintenance of a favorable highly humid condition has not been easy. Fans operating in connection with the unit coolers provide drafts with spots or areas developing which are subject to drying.

A 16½ ft. x 16½ ft. sheet of plastic of .004 inch thickness over a double stack including 130 crates has provided excellent conditions to the extent that roots stored will show no apparent dehydration. The initial cost for the plastic (trade name Vis-Queen) used in this test is about four cents per crate ($32.50 per roll 100 ft. x 16½ ft.). With proper care the plastic may be used over and over, also for other purposes wherever such air-tight covers might be useful.

H. E. Brewbaker, Director
Agricultural Experiment Station
The Great Western Sugar Company

Selection for Fusarium Resistance. Seedlings grown in greenhouse flats till the roots were 5 to 10 mm. in diameter can be tested for *Fusarium* yellows resistance. The older leaves of the seedlings were cut off, the roots severed under a suspension of inoculum to about 1½ inch in length and the seedlings transplanted to greenhouse flats. The flats with the inoculated seedlings were then placed in a chamber having saturated humidity and a temperature of 30 to 32° C. where they were left for seven days. When inbred lines were tested, striking differences in resistance were apparent between lines (see photo). One Great Western variety, selected in the field for resistance, showed a gain in resistance over its parent when tested by the above method.

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Variation in resistance to *Fusarium* of S_1 inbreds of sugar beets following artificial inoculation. White stakes limit the lines. Note line in upper left is comparitively resistant.

Types of Bags for Self-Pollination. In 1954, 749 comparisons indicated that untreated bleached Kraft (Snowfibre) bags yielded 17 percent more seed per bag than bags of the same size made of 27-pound parchment. Respective numbers of seed per bag were 48.5 and 41.4. Scalding in the parchment bags probably accounted for the difference.

Four different types of bags and bag treatments were tested for seed set on 170 different plants in 1955. The mean seeds set per bag are summarized below:

Snowfibre (untreated)	Parchment (untreated)	Snowfibre Silicone Treated (heat cured)	Snowfibre Silicone Treated (air dried)
39.0	33.6	44.7	47.4

The silicone treated bags weathered less than the untreated bags. Uncured bags weathered more than heat-cured bags but had sufficient water repellancy for use. Silicone treatment definitely does not lower seed yield and perhaps may increase it.

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